SCIENTIFIC AMERICAN SUPPLEMENT. No 936

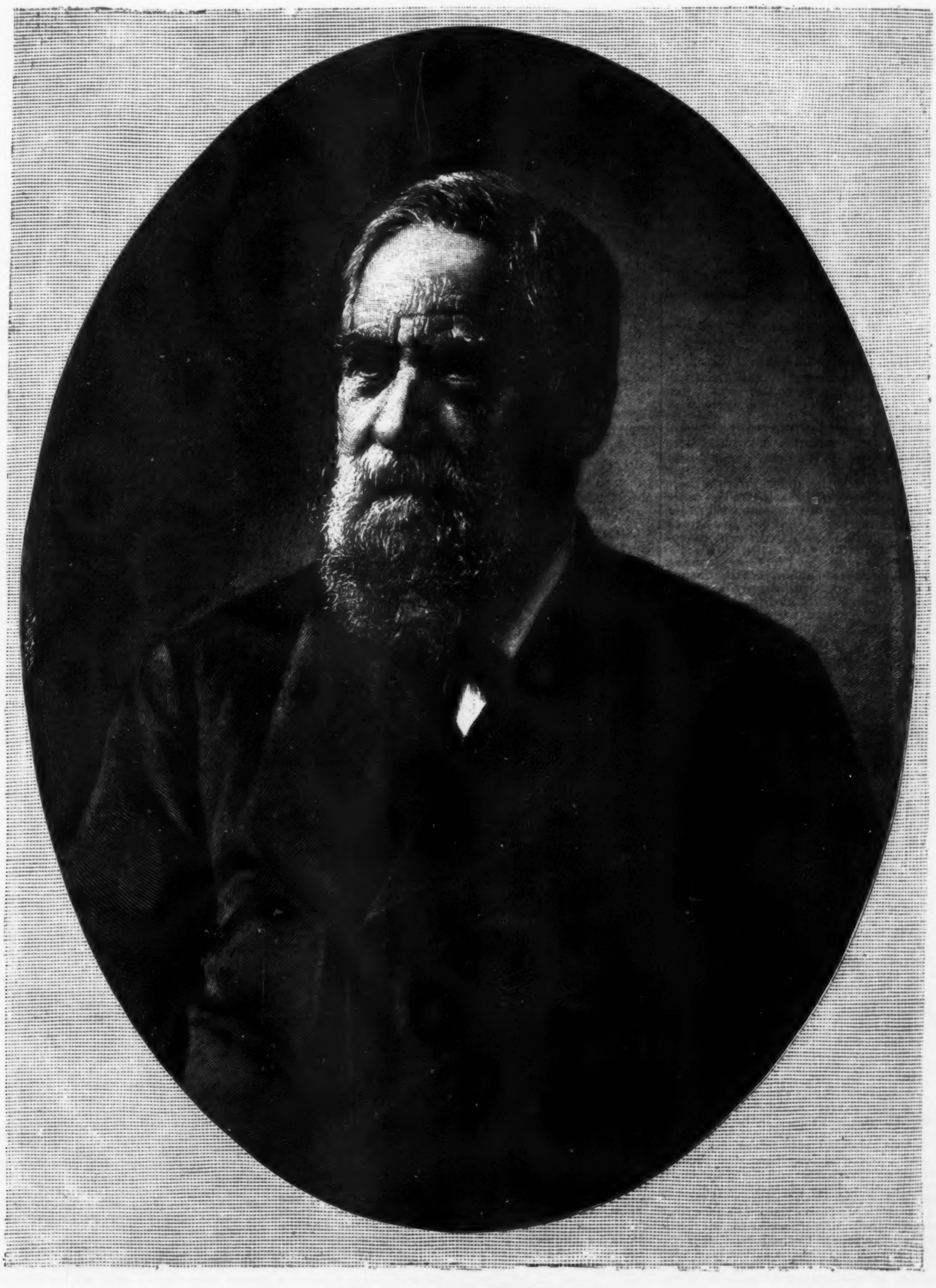
Scientific American Supplement, Vol. XXXVI. No. 936
Scientific American, established 1845.

NEW YORK, DECEMBER 9, 1893.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

MAX V. PETTENKOFER.

ALTHOUGH Germany has tried since 1860 to obtain political ripeness, she still seems destined to become the seat of mental overproduction. In connection with many questions of the day, this is noticeable in the flood of printed matter, but it is demonstrated in a different way in connection with a question which, from being a subject of only private scientific study, has become the center of public interest; that is the cholera question. Even outside of Germany, and not only in medical circles, those who are interested in this subject have divided themselves into two groups, the foci of which are two German savants, Pettenkofer and Koch. Both of these men have done much for their science, and Pettenkofer has developed a wonderful many-sidedness in his long life (he is now nearly 80 years old). He has performed valuable work, not only in that field which touches the care of health, but also in the departments of organic and inorganic chemistry, physiology and the branches connected



MAX V. PETTENKOFER.

therewith, and in the technic of engineering. His name has been rendered famous all over the world by his views, which he has held for nearly forty years, in regard to the appearance of contagious diseases, especially cholera and typhus fever, which he believes to be closely connected with certain conditions of time and place, the investigation of these conditions, and the measures—founded on the results of this investigation—taken for the sanitation of the larger European cities. This study had to be directed especially toward that disease which appears as the scourge of Europe in the nineteenth century. In fact, Pettenkofer's works on epidemics had their origin in one cholera epidemic and his latest writings treat of another. The former was in Bavaria, in 1854, and the latter in Hamburg, in 1892. His large work "On the Present Stand of the Cholera Question," which appeared in 1887, contains the fullest exposition of Pettenkofer's theory. According to this, cholera and some other contagious diseases, especially those of the digestive organs, are never carried directly from man to man, but are transmitted only under favorable conditions of the ground and the atmosphere, and only so far as those who are exposed to the contagion are susceptible. These three necessary conditions for the spread of disease he sets down as, "Infection, disposition of time and place, and personal disposition," and compares them with the x, y and z of an algebraic equation.

This theory became best known in connection with the second condition, the disposition of time and place, which belongs peculiarly to Pettenkofer. He believed he found the changing, the creating power in moisture; for the disposition of time, especially in the change in the rainfall; for the disposition of place, in the influence of the dampness of the ground, the latter being generally dependent on the former. Where this influence is subject to many changes, in porous ground where the amount of dampness varies, there, according to Pettenkofer, the disposition of place is much affected by the marked change in the level of the ground water. In 1887 Pettenkofer saw nothing in the ground water but "under certain conditions the best index for the movement of the water, for the change in the saturation of the porous layers of earth above the ground water." He considered it neither a conductor of the pollution of the ground—an opinion which he expressed in 1854 and afterward abandoned—nor as a protecting water seal for the saturated layers of earth against the decay of organic matter contained therein, but rather as a natural device for registering the amount of dampness contained in the upper strata of the ground. If it sinks much below the highest level, then, according to Pettenkofer, we have in central Europe the conditions of time and place which are most likely to cause disease.

Besides making special investigations in regard to the nature of the pollution and decomposition of the ground, the Pettenkofer school occupied itself with finding the widest possible proof of the law instead of first seeking the cause. The search for this proof was extended over India, especially to the present home of Asiatic cholera, Bengal. Only there, instead of using the changes in the ground water, the changes in the rainfall were employed, although the former often depends on the latter. In parts of India where the rainfall was abundant, particularly in Calcutta, the same conditions were found as in central Europe. Where there was a decrease in the amount of rain there was an increase in the danger of disease. On the other hand, Robert Koch, the leader of the commission sent to Egypt and British India in 1883, not only discovered the schizomycetes—which he considered the constant companion and in all probability the cause of this disease—but he was assured by the health officers of many Indian cities that the danger of cholera had diminished considerably since a sanitary water supply had been provided, and thus the possibility of direct infection, and, at the same time, the fact that the bad drinking water used heretofore had been a means of carrying the same, was proved. It is well known that in the explanation given by Koch and his followers of the last two German cholera epidemics, 1892-93 in Hamburg-Altona, and in 1893 in Neirleben, the comma bacillus and the impure water supply were named as the cause of the trouble, and that in the epidemic in Hamburg, which was even worse, such a pollution of the water could not be established. The report of the commission appeared in the same year, 1887, as Pettenkofer's chief work on the cholera question, and therefore the aged investigator could not take a stand against these views. He did this, however, in a book that appeared later and also in two articles treating of the Hamburg epidemic, in which he combated the idea that schizomycetes were the cause of the epidemic, and pointed out the correspondence of the unusual drought of 1892 with what he called the disposition of time. The undersigned can certainly testify that the ground water sank very low that summer. But Pettenkofer went a step further, for he admitted the probability that the unfiltered Elbe water of the Hamburg supply polluted the ground of the city. In this connection it will also be found that Pettenkofer allows that, under certain conditions, the ground water contributes by infiltration to the pollution of the soil.

This study of the ground water is of the greatest importance, because it opens not only the prospect of discovering the cause of Pettenkofer's laws, but also of finding a connection between them and the results of bacteriological research. Instead of trying to find such a connection between the two theories, of which Germany should be equally proud, there has been, hitherto, hostility between the two schools. The undersigned, not being a physician, found in the views thus expressed a weapon which he thought it his duty to sharpen and use immediately against our common enemy. Professor Huppe, of Prague, is the first physician who, in connection with an epidemic—the Hamburg epidemic of 1892 above referred to—explained the formation of cholera germs bacteriologically by means of vegetation of the schizomycetes outside of the body, in decaying matter. His presentation of the subject injures Pettenkofer's theory, as well as that of the undersigned, because it simply treats them together, and furthermore attacks their correctness in regard to the Hamburg epidemic. In regard to the former, this correctness has been spoken of; for the latter it is sufficient to say that, according to the statistics taken by Huppe himself, of the spread of cholera in the Hamburg districts, the number of cases and the mortality in the unhealthy infiltration district were more than double what they were where the ground water had a better fall.

From a consideration of the whole subject, we might draw the happy conclusion that all of these competitive theories in regard to the Hamburg epidemic are essentially correct and can be reconciled. The disposition of time and place explains the special danger in the lower Elbe district during that year; the impurity of the water supply, the trouble in the city of Hamburg, and the fall of the ground water, that in her eastern and southern portions. Koch's bacteriological discovery contains the key to the explanation of the infection, Huppe's theory an attempt to throw some light on the path of infection; but Pettenkofer has the undying honor of having been the first to discover one of these theories, of having adhered to it for years, and of having worked it out.

For the above we are indebted to an article by Wilhelm Krebs in the *Illustrirte Zeitung.*

FRANCIS PARKMAN.

ON the occasion of the publication of Dr. Francis Parkman's last work, "A Half Century of Conflict," completing his historical contribution to our literature, the *Outlook* commented at length upon the significance and characteristics of that work and upon the qualities of the man. Now comes the news that, in the fullness of years and honors, Dr. Parkman has gone to his rest. This familiar phrase means much in his case; for he had been all his mature life fighting against disease and doing his work under conditions which would have discouraged any man of less nobility and steadfastness of purpose. Born in 1823, of a distinguished New England ancestry, Dr. Parkman was prepared for college at Chauncy Hall, graduated from Harvard, and discovered very early the love of nature and of historical research which distinguished his later life. As a boy he was given to the reading of colonial history and to long wanderings in the woods of upper New England and of central New York, a good deal of his leisure being spent in the picturesque region of Lake George and Lake Champlain, which he was afterward to describe with such loving fidelity.

Like many another man destined to achieve distinction in the field of literature, Dr. Parkman attempted to become a lawyer, but speedily wearied of the profession, and in 1846 made the memorable journey across

FRANCIS PARKMAN.

the plains which furnished the material for the first of his books, "The Oregon Trail." That journey was distinctly educational for the man who was to describe Indian warfare and Indian life with wonderful vividness and accuracy, ate, drank, and slept with the Indians, watched their dances, heard their legends, and entered into the secrets of their temperament and inheritance. The exposure of that journey laid the seeds of the disease which, but for his indomitable will, would have rendered nugatory his great talents and his ample knowledge.

"The Oregon Trail" was followed in 1851 by "The Conspiracy of Pontiac," in the preface of which the historian commented briefly upon the conditions under which the work had been done. "For about three years," he wrote, "the light of day was insupportable, and every attempt at reading or writing completely debarred. Under these circumstances, the task of sifting the materials and composing the work was begun and finished. The papers were repeatedly read aloud by an amanuensis, copious notes and extracts were made and the narrative written down from my dictation."

It is always possible for a strong nature to wrest power even from the most adverse conditions, and this truth, so magnificently illustrated by Dante, finds a shining example in the story of Dr. Parkman's life. One thing gained from disease and weakness, among other things, comes out in a phrase in the same preface: "This process, though extremely slow and laborious, was not without its advantages, and I am well convinced that the authorities have been more minutely examined, more scrupulously collated, and more thoroughly digested than they would have been under other circumstances" "The Conspiracy of Pontiac" was the initial volume in a series of histories covering the varied and romantic episode of the struggle of the French for a foothold upon this continent, and the memorable war of races which wrested power from their hands and lodged it in the hands of the English speaking peoples. No American historian has ever had richer material to deal with, nor has any had material more widely scattered and more difficult of access. In spite of his physical infirmities, Dr. Parkman made many visits to Europe, examined a vast mass of official documents, explored archives, and, with tireless persistency, made himself the master of the great body of material, written in different languages, preserved in different places, and never before brought together and collated. It was a noble work, both from the intellectual and the moral side; and, recalling the self-sacrifice, the heroic conquest of pain and weakness, the patient devotion to high ideals of exactness and thoroughness, which went into the work, it is no exaggeration to say that Dr. Parkman's life was heroic.

Upon the quality of that work it is unnecessary to comment at this time. Dr. Parkman brought to his task a vivid historical imagination, which dealt with the past as if it were the present, and which realized the figures of bygone ages as if they were the men and women of to day. "The Old Regime in Canada," "Montcalm and Wolfe," "The Jesuits in North America," and "The Pioneers of France in the New World" are among the most brilliant books, in point of style, which have been written on this continent. Accurate to the last degree so far as the historical statement is concerned, they have the freshness, the variety, and the living interest of the best fiction. Dr. Parkman was a literary artist as well as a historian. He did not belong to that group of historians who believe that the proper way to write history is to edit the original documents and leave the task of discerning between the essentials and non-essentials to a patient reading public. On the contrary, Dr. Parkman believed that the task of the historian is to assimilate the history of the past, to discern its great lines, to recognize its influential figures, and to give the story coherent movement, living interest, and dramatic power. He lived to finish in his age the work planned in his youth, and he leaves behind him a memory of heroic devotion and of lasting achievement. His passionate love of roses seemed a part of the man's nature, for he was pre-eminently a gentleman in the refinement, the dignity, and the elevation of his life. No man has been a worthier custodian of the traditions of literature than Dr. Parkman.—*The Outlook.*

FRANCIS PARKMAN.

FRANCIS PARKMAN died November, 1893, after a short illness at his home, on the banks of Jamaica Pond, in Boston. It does not come within our province to speak of Mr. Parkman's great achievements as a man of letters which have added such luster to American scholarship; nor is it our purpose here to repeat the story of the fortitude, endurance and singleness of purpose which enabled him to complete, under the most trying physical limitations, the work which, as a youth, he laid out for himself, and upon which he labored heroically during half a century. His life has made the nation greater; and its example is a blessing to every American. His love of nature was one of the strong characteristics of the man; he loved to woo her in her untamed solitudes, and to paint in glowing words the beauties of the forests and the streams, which were the great stages upon which his characters played their parts. It vitalized his pages and made his descriptions of our American forests of two centuries ago at once the most picturesque and the most accurate which have been written.

Every one who has read one of Mr. Parkman's histories knows how he loved nature, but many of our younger readers, perhaps, will have forgotten that twenty years ago he was a successful and distinguished horticulturist. When the historian of the conquerors of the great lakes and rivers of the continent could no longer follow their footsteps in the forest he found solace in the garden, where he tried to regain his lost health and strength. It is as a rosarian that Mr. Parkman is best known among horticulturists. He was one of the first Americans to cultivate a collection of roses upon scientific principles, and his example has done more, perhaps, than that of any other man to raise the standard of rose-growing in America to its present excellence. "The Book of Roses," which he published in 1866, and which embodies sound cultural instruction, with an account of the different races of his favorite flower, is still the best work within the limits of this field that has been written on the subject.

In 1861, a small collection of plants, purchased from a nurseryman at Yokohama by Dr. George R. Hall, was placed in Mr. Parkman's hands to propagate. This was probably the first collection of plants sent directly to America from Japan; in it were several plants now well known in our gardens, including the double-flowered apple, which bears Mr. Parkman's name and which is still standing in his garden, several Retinosporas, Thuya dolobrata, Rhododendron brachycarpum, Andromeda Japonica, the double-flowered wistaria and bulbs of the familiar Lilium auratum, which Mr. Parkman flowered before any one else in America or Europe.

To the cultivation of lilies, which were always favorites with him, he devoted much attention, trying to improve them by cross-breeding; in this he had at least one conspicuous success with Lilium Parkmani, which he raised by crossing Lilium auratum with Lilium speciosum. A paper from his pen published in the "Bulletin of the Bussey Institution of Harvard College," records the results of his experiments in hybridizing lilies. In the improvement of plants by cross-breeding, Mr. Parkman was always interested, and many good varieties of iris, delphinium, peony and poppy were born in his garden. He was one of the first Americans to grow a collection of herbaceous plants; and his garden was always full of interesting shrubs, bulbs and hardy perennials.

For a short time Mr. Parkman was professor of horticulture in Harvard University, which he served faithfully for many years as an overseer and then as a fellow, and for two years he was president of the Massachusetts Horticultural Society.

In the development of horticulture in America, Mr. Parkman's influence has been considerable and always in the right direction, and of those Americans who have practiced the gentle art not one has brought to it a more sincere love or a keener intelligence.—*Garden and Forest.*

IN Witu, east Africa, they are making sugar from cotton seed that is said to be fifteen times sweeter than that made from Louisiana sugar cane.

THE COLUMBIAN EXPOSITION.

III. LIBERAL ARTS—FRANCE, BELGIUM, RUSSIA, NORWAY, DENMARK, AND ITALY.

By L. P. GRATACAP.

THE pavilion of France is massive and richly carved. It consists of a series of chambers whose lintels on the main aisle are supported by female termini, and are centrally controlled by a classic porch and dome beneath which is placed the statue of the Republic. The design is not as forcible as in the case of Germany, nor is the composition as grandiose, sustained and imposing. On either side of the entrance are two symbolic obeliscal pilasters of Peace and Labor, and two rather penumbral frescoes of Manufacture and Science. At the very entrance of the Art Exhibit the visitor meets the huge bronze vase, Louis XV. style, made by the *cire perdu* process, a procedure first employed by Rhæcus of Samos, 700 B. C., and revived in the fifteenth century. Immediately at hand is an exhibit of antique furniture of A. Beurdeley, of great elegance and tender modeling in the fashion of Louis XV. and XVI. Within is an imposing display of Sevres ware, upon a platform in three stages. Here are large vases in single colors, ornamented with flower designs, raised decoration, etc., all touching the limits of refined ceramics, but not always grateful to the taste, jaded by merciless repetitions of insipid prettinesses. They are naturally marvels of technique, and of course supremely rare and lonely in their way and above price. The Gobelin tapestries on the walls of this room are amazingly fine in their joyousness of color, their artistic bloom and magnificence of texture. These beautiful textile paintings on the walls, the superb vases grouped on cabinets or upon the pyramidal platform in the center and the glimpses outward into apartments of beautiful furniture (*ameublement*) make this inclosure one of the most effectively artistic in this building, with an expression of conscious supremacy not seen elsewhere. The furniture and carvings of Hamot, Poirier, and Remon, Sormani, that of Leborgne and Louchet-Bernard are celebrated, and are represented in separate rooms. The bronze exhibit of Thiebaut Brothers is composed around the large and magnificent vine vase of Gustave Dore, an orgie in metal, full of *abandon*, yet replete with artistic grace. It is rather artificial, and most of the bronzes here are lacking in original power, in the Barye gift of naturalness. In the Barbedienne collection are several pieces of Barye. The art bronzes are very varied, but tediously insignificant and theatrical. The silversmith work of Christofle is chaste and elegant, but fails to surpass, even if it rivals, the original work of Tiffany. Susse Brothers exhibit the great group of the Defense of the Flag, by A. Croisy, a masterly composition, and if a little formally symmetrical in arrangement, yet remarkably clever in clearness and French vigor.

Many of the other bronzes here are weak and tiresome, though bearing the stamp of technical distinction. Perhaps among the more notable is that of the Spirit Guarding the Secret of the Tomb; finely modeled, though not very acutely poetic and inspiring. There are numerous lamps, chandeliers, boudoirs, cabinets, glorious fabrics, and the thousand choice and elegant appointments in dress and furniture in which France excels. The French exhibit is of extraordinary value, and in its careful arrangement, its discriminating separation into subjects, and the high order of its material perhaps leads all the foreign sections.

Belgium exhibits some beautiful delf ware, simple, unostentatious and charmingly natural. It is instructive to note the simple treatment here of classical subjects and the always suggested realism of rural scenes. It affords a refreshing contrast to the high-flown style of much of the French ornamentation. It is with a sense of real relief that one encounters this kind of treatment after the superabundant posing and balancing, gesturing and smirking of French faces and legs. Probably one of the most beautiful bronze works in the Fair is the huge vase in the Belgium section, called the twelve-fronted vase, cast also by the lost wax (*cire perdu*) process. Its form is delightful, but the ornamentation a little mixed and not so pleasing, being a mixture of archaic and natural patterns. Perhaps one of the most charming vases in the Fair is a large majolica piece in the Belgian section, about 5 feet high, of a delicate mottled blue and white, and holding upon its summit a branch of autumnal grapevine, while three amori or Cupids in yellow encircle the neck. The whole coloring is deliciously harmonious and the action of the boys admirably truthful, a capital illustration of the natural treatment, and deservingly successful from a purely artistic point of view. There are here very noble furniture designs (F. Rasel) and very splendid tapestry.

You enter the Russian exhibit through an archaic and massive doorway, part of a remarkable wood pavilion, the work of Petrovo Ropette, a combination of Byzantine ideas, perhaps, with a heavy Slavic force of execution, very unusual and half displeasing. The structure seems to invite you to something extraordinary, and you are not disappointed. The objects here are new indeed, and famously interesting. You are delighted with the sensations they impart. There is a kind of barbaric splendor and even fascinating rudeness in what you find here. The malachite tables, mantels and vases, the lapis-lazuli vases with gold moun ings, labradorite objects, rhodonite inkstands and flower urns, models of the *iconostasis*, enamel ware, wealth of gold and silver designs, all mingle into a rich confusion that fully satisfies the greed of sense. The enamel work of Ovchinnikoff is most gem-like. It consists of tinted glass insertions in woven and reticulated gold and silver, and is thrown into many forms; small vases, plates, pocketbooks, chatelaines, receivers, watch covers, jewel boxes, etc., etc., being made of it. Nothing can surpass it in artistic sumptuousness in a peculiarly fascinating mixture of barbaric excess and cultivated color sense. It is unique, unapproachable! The American efforts at this enamel work, though promising, fall far short of these supreme results. Then there are marvelous mosaic panels in gold-encrusted cabinets, very delicately colored with shades of green and brown jasper or slate, and very artfully composed. Here are jade (nephrite) and rock crystal dishes, huge rhodonite vases, a pomp of needlework and interesting wood painting. Here are the famous Russian bronzes: rustic groups, animal groups, life outdoors, depicted in bronze, that has the effect of tableaux, and tells the story of suffering, hardship, humor and natural scenes with unfailing accuracy, naturalness and interest. In all their work the *design* is strange, fresh, satisfying, indigenous. One is inclined upon the first impulse to admire even the dolls of Mr. Bopohoba, who somewhat consciously informs the visitor that "he begs to *considerer* for his articles only those that have his initials." But the surprises are not over. The hand painting on papier mache, revealed in trays, albums, pocketbooks, bowls, is full of interest, brilliancy and novelty. Here are pearl-incased medallions of the Christ and the Virgin, here rich peculiar furniture, here red, gold and blue stuffs, magnificent as a bishop's cope; here great samovars, and here again a depot of furs, endless in their profusion. There is little doubt that in positive surprises nothing equals the Russian exhibit. It is a perpetual succession of astonishment and breathless interest.

We encounter again the enamel work of Russia, with very solid and original silver ware in Norway. Some designs in lamps in this section were especially curious and satisfactory. The Norwegian wood carving is worthy of study, and can be used in a comparative study with that of Switzerland. It is more beautiful, broad and significant. In the Netherlands the delf ware again challenges our admiration. It is different from the Belgian, or appears so, seeming more simple, with forms less modified by an effort at novelty. These are charmingly simple and agreeable. The plaques framed in wood were especially pleasing.

The Danish terra-cotta and blue ware was noticeable. The reproductions of Etruscan ware were interesting and are well known. The silver work here was mostly in hard brilliant surfaces and quite striking, but the jewelry is affected by archaic and prehistoric types, and is, on the whole, rather rude and gross in conception. Two bronze candelabra in this exhibit from F. Doberck & Son, of Copenhagen, were, in their way, without a rival. The blue ware was very attractive, the pieces surmounted by perforated summits, and in the candlesticks by a perforated web between the branching arms, being especially good. The earthenware exhibit, with metal dripping under the glaze, is interesting, suggesting the American Rockwood and the English Eltonware. In Italy the majolica was exuberantly exhibited; the great pitcher with the Triumph of Neptune depicted upon it was a *tour de force* in coloring, though tentative in drawing. There were many characteristic examples of this lively ware in interwoven figures upon flower pots. The colors of this majolica, we were informed, are not exactly just to the originals. The *Nove* (?) ware of Italy is flamboyant and yet delicate, peculiar in design and employs flower decoration in abundance. It is *faience*, suggesting Palissy in treatment, but more nearly porcelain. The *Nove* ware of Naples and the Florentine ware with figure decoration are most notable expositions of this material, beautiful in color and natural or quaint in arrangement. The two grand vases on the main aisle, with the mosaic plaque by Mollica, were ideal combinations of freshness, gayety and sweetness of color and design. The bronzes had merit, and the many Parian marble figures were well made, but seem discouragingly uninteresting. The wood carving of Italy is the most remarkable in the Fair. It presents half-size figures in design of the 18th century, but not overburdened with detail and possessing a beautiful luster. The inlaid wood and furniture of Italy are magnificent. The Venetian glass was well represented, but, we thought, poorly displayed; indeed, the whole Italian exhibit seemed crowded and hopelessly disarranged. There appeared to be insufficient room. It lacked symmetry, order and effectiveness, although so much of it challenged the highest praise in material and workmanship.

In the Indian exhibit, a rather slight matter, we admired the Benares ware in brass, the Moradabad brass enamel work, the Tanjore work in silver on copper and the various gold thread embroideries, which were novel and attractive in their intricacy and labyrinthine patterns. Near this booth was a reproduction of an Indian domicile, with fenestrated screens cut from teak wood and furnished with hammocks, chairs and tables, lamps and rugs in Oriental style, of much interest.

LOSSES OF SUGAR DURING EVAPORATION AND CONCENTRATION.*

I ATTEMPTED during the last season to determine the extent of the mechanical losses of sugar during these two operations in the course of manufacture, and although the work that I present here remains imperfect, I preferred not to remain in silence with the figures in hand that I had obtained, and have drawn some conclusions from them. The imperfect means that I have had in determining these losses I shall now relate. I took, regularly as possible, samples of condensed water from various vessels of the triple effect, from the ammoniacal water and from the water coming from the foot tank of the air pump of the triple effect, and of the water from the foot tank of the vacuum pan or pump. These waters, containing very little sugar, could not be analyzed directly by the saccharometer nor by the copper test. I therefore concentrated them to one tenth of their original volume after having inverted the sucrose with tartaric acid some minutes before the end of the operation, and then determined the sugar by the Fehling test.

1. *Mechanical Losses by Evaporation.*—I have never observed any notable quantity of sugar in the ammoniacal waters from the first pan of the triple effect. It is probable then that the overflows or entrainments which might be produced in these first vessels are in the catchalls. There seems then no need of improved catchalls, as the loss from these first pans does not exist when the triple effect works well.

When one finds sugar in ammoniacal waters it is more particularly at the moment when evaporation is stopped and there are tubes which leak. The steam in the heating chamber of the pan then condensing produces a vacuum relatively greater than that within the vapor space itself, and the juice of the latter by its relative pressure penetrates into the steam chamber, mixing there with the ammoniacal waters. This is but an accident, although tolerably frequent and easy to avoid.

Another extremely serious loss is the result of the entrainment from the sirup pan toward the condenser when the catchall in that direction is insufficient. This was precisely our situation last year at the factory at Pommiers, where, for certain reasons, the reheating condenser that followed the sirup pan had been removed. A small catchall remained above the pan, and this apparatus was entirely insufficient, for the loss was considerable during the early weeks of our manufacture. The examination of the waters of the foot tank of the air pump indicated that a large part of this loss came from the insufficient size of the catchall. There were found quantities of sucrose varying between 160 and 400 grammes per cubic meter of water, averaging about 300 grammes. If we examine figures for the density Baumé of the sirup coming from the last pan, we find generally the largest quantities of sugar in these waters to correspond with the highest degree Baumé in the pan. This would seem to be something other than a simple coincidence, and this coincidence would be seen more clearly if there were always a constant supply of water for the air pump, and if there were never any sudden overflows or permanent entrainment. Still further, the quantity of sugar in the water seemed to increase—not proportionately, but progressively with the concentration of the sirup.

This tended to prove that while there might be a considerable entrainment of sugar, that is to say the production of many sugar globules, the sirup needed to be in a certain condition of viscosity incident to concentration, and to the extent to which concentration was advanced the globules became more and more numerous, and at the same time of higher sugar content, which explains the progressiveness of the loss. What tends to confirm this interpretation is the comparatively complete absence of sugars in the ammoniacal waters in good normal work. Evidently the globules entrained in the first pans of the triple effect were not only of less sucrose test than those coming from the sirup pan, but still further, in quantities so low that no sugar was found in the water. The juice in ebullition in the first pans *had not then arrived at that concentration favorable to the formation of these globules.* When the juice arrives at a certain degree of concentration, permanent entrainment begins and accelerates under the double influence of the higher concentration and the greater vacuum.

The average loss of 300 grammes of sugar per cubic meter of water, which is very important because of the 2,000 cubic meters of water used by the pump during twenty-four hours, losing some 600 kilos. of sugar in a daily work of 200 tons, or about 0·3 per cent. of the weight of the beet, was too considerable, I thought, to be neglected, and Mr. Brunehaut, owner of the factory, conceived the ingenious idea of arranging in the interior of the sirup pan, near the dome, a diaphragm composed of three clusters of wooden baffle plates so arranged as to oppose the progress of the vapor without reducing the free space to the vapor leading to the condenser. This arrangement, which is, in fact, an improved catchall, was very effective. The quantity of sugar found in the water from the pump fell the next day to 38 grammes per cubic meter of water, and since this loss has been an average of 79 grammes per cubic meter, varying between the limits of 26 grammes and 158.

One time alone we found 428 grammes, but it was ascertained that the diaphragm had been displaced and let the vapor circulate without baffling.

The average of 79 grammes, though much less than that of 300, still corresponds to 0·08 per cent. of the weight of the beet, and notwithstanding this material improvement, it is probable that Mr. Brunehaut will add a Hodeck catchall to still further reduce the loss. I would suggest to all sugar manufacturers to do likewise, for I believe that there are some among them who do not suspect the importance of this loss, which is often unperceived, and further on I shall say why.

2. *Mechanical Losses in the Vacuum Pan.*—From the beginning of the last season I had thought that the mechanical losses in the vacuum pan was one of the factors in our problem, and I was surprised in not finding notable quantities of sugar in the water from the air pump of the vacuum boiling apparatus, which has only a catchall, but no Hodeck.

Desiring to know to what phase of the sugar boiling losses especially attached I took samples of water two or three times separately. First, during the evaporation of the sirup up to granulating point, then toward the middle of the strike and finally toward the end. I analyzed these three samples separately. These analyses were made on a large number of strikes and the figures obtained were as follows:

Sugar lost, acreage in grammes per cubic meter of water.

	Beginning of Strike.	Middle.	End.
Average loss	32	Trace.	Trace.
Highest loss	60	"	"
Lowest loss	22	"	"

As is here seen, it is at the beginning of the strike only that a perceptible loss of sugar occurs, while toward the middle and toward the end no sugar can be perceived in the water by any ordinary test.

These unexpected results, absolutely in disaccord with the conclusions of our honorable colleague, Mr. Vivien, drawn from experiments made by him in 1891 at Bucy-les-Pierrepont, seemed to be the *reverse of what occurs in the triple effect.* In fact, it is a fresh confirmation of the idea that I have previously announced, that the production of a large number of sugar globules will depend especially on the physical condition of the sirup. In the strike pan the physical condition of the sirup favorable to the formation of sugar globules during boiling changes as soon as grain is formed, and it then no longer has the homogeneity nor the same viscosity. If overflows are produced, these are not globules, but plates of masse cuite which are too heavy to be entrained very far. One portion falls to the apparatus or collects in the dome and falls therefrom later on, and a small portion passes into the catchall and is usually retained there.

Many will, however, be astonished, as I was myself, that even at the first phase of the final boiling the loss was not greater: but if one would consider that the speed of the vapor in the interior of the vacuum pan is but about one-sixth of that in the sirup pan of the triple effect, and if one would consider also that the

* Translated for *The Louisiana Planter* from *Le Bulletin de l'Association des Chemistes de France*, by M. Breton.

heating surface is higher in the vacuum pan, which favors the retention of the little globules, there is then nothing astonishing in this, that the loss in sugar in the vacuum pan should be relatively low as compared with the loss in the evaporating apparatus.

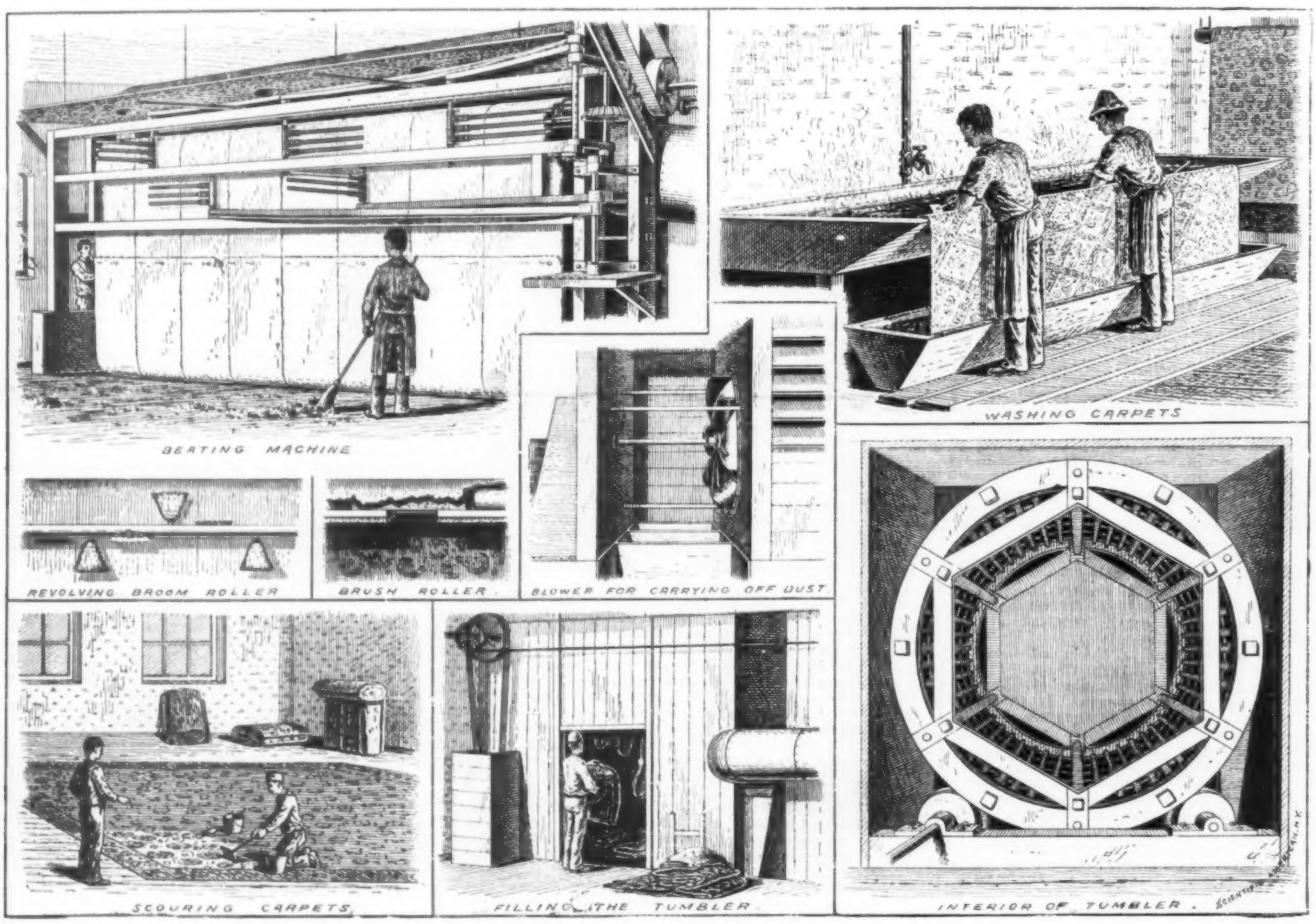
The physical loss due to evaporation was with me about 0·08 per cent. of the weight of the beets, and in the vacuum pan about 0·01 per cent., making a total loss of 0·09 per cent. of the weight of the beets.

These figures accord in a remarkable way with those published last year by Mr. Battut. It is probable that these figures are not absolutely correct, and that every factory may have a special average, according to the greater or less perfection of its machinery and general outfit.

I have said herein that with an insufficient apparatus the physical loss might become large during evaporation, which was my experience in the last campaign. I have added that some manufacturers do not even suspect the importance of this loss, and for the reason that they have a cooler to chill the waters coming from the air pumps of the triple effect and the vacuum pan; and in making their analyses they take the water from the same basin, analyzing these deceptive waters, rarely discovering the presence of sugar, which is, so to speak, destroyed beforb it arrives by the micro-organisms which multiply in these waters. It is here, probably, that we should search for the source of the contradiction which occurs between my results and those of Mr. Vivien, announced last year. The samples of water taken should be taken at the tank at the air pump, and never elsewhere.

STEAM CARPET CLEANING.

THE illustrations of this subject were taken from the plant of Thomas J. Stewart, Jersey City. The new method of cleaning carpets by machinery removes the dirt and dust more effectually than by the old process of beating by hand, saving both time and labor and many a bruised knuckle. Impurities such as sticks, straws, sand, gravel, leavings of food, fragments of tobacco, ashes of coal and wood, etc., brought in from the street on the feet, make it almost impossible for a person to beat it out by hand evenly and thoroughly. The carpets to be cleaned are first taken from residences, business offices, etc., and the frail and good strong carpets separated from each other. About 250 yards of the good carpets are placed loosely in what is called the tumbler. This tumbler is wheel shaped and hollow and is driven by friction. It is 16 feet in diameter and 8 feet in width and made of maple wood. The two circular sides of the tumbler are braced together securely by six wooden carriers about 18 inches in width and about 6 inches in thickness. Between the carriers on the under side is a network made of wood, through the meshes of which the dirt falls as the tumbler revolves. The tumbler makes about twenty revolutions per minute, the carpets being taken up by the carriers to a certain height and dropped and taken up again, causing the dirt and impurities to fall out and down through the meshes, where it is sucked up through a 50 inch pipe by means of a 7 foot Blackman ventilating wheel. The tumbling process continues for about 1½ hours. The carpets are then removed to the scouring room, to have the grease spots and stains removed from them. The frail carpets go through a beating process. The framework of this machine is made mostly of wood, at the top of which is a double wooden roller. About 150 yards of carpet is pinned together with the face inside. One end is passed between these rollers and over a brush roller, the ends of the carpets are then pinned together and the material allowed to hang down to the floor. When the machine is set in motion the rollers revolve, causing the carpet to revolve also. On the outside, close to the back of carpet, attached to the framework of machine are a number of beaters. These beaters are made of hickory wood and are about 4 feet in length and about 1½ inches in width. These sticks are fastened in a socket connected to the shafts. The beaters are connected to the machinery by means of belting so arranged that when in motion they go back and forth, striking the carpet and leaving it instantly, whacking out the dust at every stroke. On the other side of the machine is another roller, attached to which are a number of brooms which revolve around, sweeping off the dust during the process of cleaning. The brush roller which sweeps off the face of the carpet on the inside is about 15 inches in diameter. The backs of the brushes are circular shaped and screwed fast to the roller. They are 18 inches in length, 5 inches in width, and made of manila. The process of beating continues for about one hour. They are then taken away to be washed or scoured. The washing or scouring trough is 20 feet in length and 3 feet in width and about 2 feet in depth. Hot water is used with a renovating compound to take out the grease and stains. After washing and drying, a finishing powder is swept over it which takes away the washed appearance. Old faded-out carpets by using a renovating compound can be made to look almost as fresh and new as ever. The establishment uses a 125 horse power engine with 80 pounds of steam.



STEAM CARPET CLEANING.

UTILITY OF GYPSUM IN OKLAHOMA.

THERE is such a universal presence of the mineral known as gypsum in Oklahoma as to make it one of the distinguishing features of this Territory. This fact can be well verified by every person who has dug a well, excavated a cellar or provided a storm cave. Gypsum is also noticeable in upturned furrows and cultivated soil throughout the improved portions of Oklahoma. In many places it crops out in large bodies, but more generally in small particles, thin flakes, disconnected spars a few inches long, and in lumps which readily sliver in thin sheets resembling mica.

To those not familiar with gypsum I will here define its essential qualities and indicate its utility. The word is of Greek origin, and this crystalline mineral is believed to have been largely used in sculpture and statuary among the ancients on account of easy carving and durability. Chemically it is a bi-hydrated calcium sulphate, $Ca\,SO_4 + 2H2O$, indicating how largely oxygen and hydrogen belong to its formal composition. As it requires a heat about equal to that for melting gold or silver to decompose the liquid from its solid formation, it is an easy guess that water composes the minor half of this lustrous mineral substance. The varieties which glitter in the upturned soil of Oklahoma are recognized as selenite, from selene, in allusion to their soft yet brilliant luster. The large opaque bodies, which form like layers of rock, constitute the gypsum of commerce. But the chemical qualities only vary according to degree of deoxidation. Among the massive forms of gypsum, the satin-spar, a fibrous variety, being most readily deoxidized, is converted into a fine powder, and named plaster of Paris, as it was first marketed in that city, coming from the famous gypsum mines of Montmartre, a suburb of Paris. The finest grade of gypsum is known as alabaster. It is subtranslucent, rich amber in shading, on pale olive ground, and susceptible of brilliant polish. It is much used in sculpture, on account of easy carving and increased durability from air exposure. It is tougher than marble, more beautiful, and is much in request as frontal ornaments for brick or stone edifices.

The conversion of gypsum into plaster of Paris is done by subjecting the quarried rock to about 380 degrees Fahrenheit, to expel the moisture, then pulverizing the dry substance to a very fine powder. As only moisture and volatile matter have been expelled in this process, the addition of water to the powder returns it to its natural opaque form, except certain acids expelled by the heat, leaving it pure white, deprived of its amber luster. The grand sculptured columns and marvelous architectural display of the World's Fair buildings at Chicago, at which the civilized world has gazed with awe and wonder, are largely indebted to the Michigan gypsum quarries, just across the lake, for their magnificence. They were done in stucco and plaster of Paris, the same calcium sulphates that pervade the soil of Oklahoma.

The stucco of commerce, used for the white finish of plastered rooms, is made from gypsum rock by first pulverizing into a very fine floury powder, in mills of great power constructed for that purpose, known as plaster mills; this powder is then subjected to intense heat in large iron caldrons. The caldrons are about eight feet in diameter by four feet deep, set in rows over furnaces two or three hundred feet long. About two feet deep of floured gypsum is put in each caldron, the furnace fired, when the substance seethes and boils, surges, foams and blubbers in columns several feet high, as if it were a liquid mass. In two or three hours it ceases to boil, having evaporated a large part of its original weight, and lying dead in the bottom of the kettle. It is the stucco of commerce, so indispensable in the beautiful white walls of our dwellings. It is simply pulverized and boiled gypsum.

The fact that plaster of Paris, land plaster, and stucco will receive and retain moisture to the extent of converting a dry powder into an opaque and obdurate body, is a matter too obvious to every one to need any amplification in this writing. Exposed to common air, it is well known they will cake and harden by absorbing moisture from the air the same as if water were added to them, evidencing the important fact that they are moisture absorbents, and in a common way of speaking, water magnets, because they attract moisture; and this is the salient point for which this paper is written, because it has an estimable bearing on the economic character of the agricultural inter-

est of Oklahoma. Were I not conscious that gypsum forms a large part of the soils and under-formations of this Territory, this article had not been written, as it would be irrelevant and too far-fetched to be of public interest.

Now I come to the pith of my subject—gypsum as a moisture magnet—apologizing for the apparent unscientific application of the term. However, I am confident that chemists will agree with me in the fact that any substance which will absorb moisture will also absorb acid gases, ammonias, floating odors, ozone, infusoria, and even the bacteria of contagious diseases. If such be the fact, then we have gypsum taking its place in line as a stalwart friend of blooming health, as well as a shield to the farmer's wealth. It will assist in locking up the volatile spores of disease and invigorating failing vegetable energy with the elixir of life.

I have thus amplified on the character and quality of gypsum, and its utility, for the direct purpose of calling public attention to its economic value as existing and abundantly pervading Oklahoma soil; more particularly to its characteristic as a moisture magnet or absorbent, and correlatively as an absorbent of the various gases and ammonias which enter into the structural integration of organic life. It is calling public attention to the beautiful lustrous flakes of satin spar, to the shining selenite particles which the well digger throws out with his spade or the farmer exposes on the upturned furrow—friends to health and shields against withering, hot winds.

The form of gypsum most known to agriculturists is the crude rock ground to a dust, and well known as land plaster in commercial circles. In Eastern and Northern States farmers buy it by the ton, and sow drouth of long duration, keeping vegetation fresh and vigorous through periods of sixty to ninety days' absence of rain.

It is a matter of common observation in countries where land plaster is used that, under a slight coating, soil retains moisture at the surface, when a few feet away without the plaster the soil is dry as powder several inches deep. The cost of land plaster at the mines in Michigan averages about seventy cents a ton, and farmers haul it great distances on sleighs in winter for spring top dressing of meadows, finding it a profitable investment in superior quality and enlarged product of grass, and sowed on wheat fields it perceptibly tells on the quality and yield of grain. It is a very common thing in Michigan and New York to see farmers dusting their corn fields with a spoonful of plaster to each hill of corn, or on dewy mornings strewing it over their gardens.

Many suppose gypsum to have the characteristic of lime, alkali, or potash, and thus the word "gyp," as applied to drastic kinds of water, has relation to gypsum; but such is not the case. In itself it is almost tasteless, and not soluble in water, but an absorbent, not tainting water as do the soluble substances. It is soft and yielding as crude rock, minus of grit, susceptible of carving in any form without dulling an ordinary sharp edged instrument. In massive rock form it abounds in various parts of the Chickasaw, Choctaw and Comanche reservations, but whether in beds sufficient for profitable mining is not yet known, as this Territory has never had a thorough geological survey. But its general presence in Oklahoma as a moisture magnet must be of incalculable value as a shield to vegetation against drouth, as well as a valuable deodorizer; and when used as a top dressing, is an effective means of exterminating vegetable parasites. Finally, if, as claimed by those using gypsum as a deodorizer, it is a successful absorbent of acid gases, then it is a certain absorbent of the spores and effluvia concomitant with malarial and epidemic disease; and I believe that experiment will sustain me in the views here taken.—*J. W. Evarts, in The Oklahoma Magazine.*

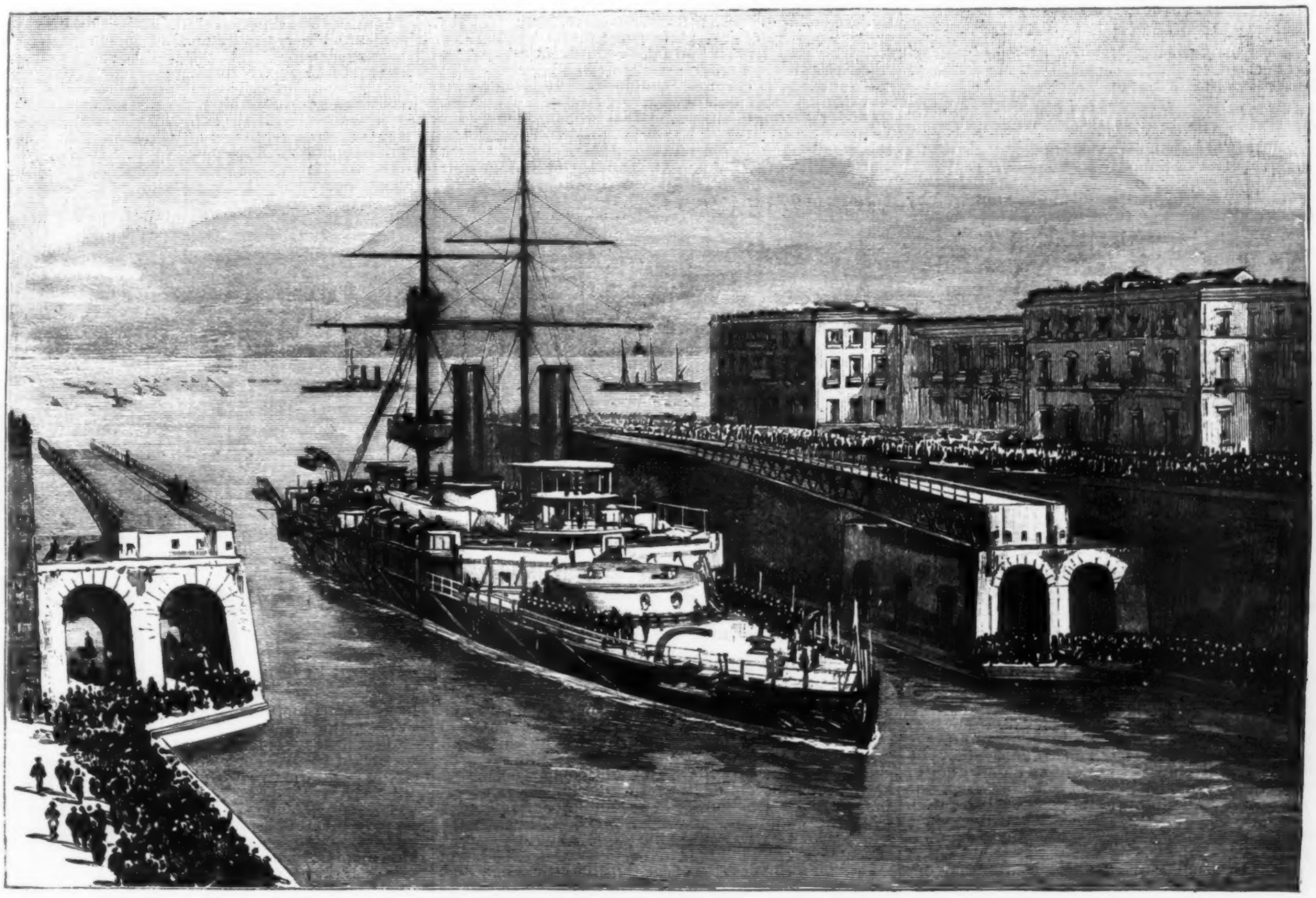
it broadcast in early spring on meadows, grain fields and gardens, with a belief that it keeps the land surface moist and conducts ammonias and gases into the soil. They have found by placing open shallow boxes of plaster in stables, cellars and other places where foul odors abound, that the apartments are quite free from odors, while the boxes become rank with offensive gases. The plaster thus surcharged with acids and ammonias is placed around growing plants, trees and shrubbery with marvelous results in increased growth and vigor. The utility of plaster in this respect is so great as to be almost indispensable in greenhouses and gardens. The dusting of orchards with it on dewy mornings is fatal to insect life, perhaps from its liberation of its sulphurous acid gas, insuring abundant crops of fine and sound fruit. Cabbage and other plant lice and moths of all kinds fail to multiply in gardens strewn with land plaster. Even vermin dislike it; for when plaster of Paris is mixed with corn meal, rats and mice will eat it readily, as it is tasteless; and the moment they sip a little water it forms a solid stone in the stomach, resulting in sudden death.

Chemists do not credit gypsum with fertilizing or neutralizing properties, as with alkalies or potassium; but as an absorbent its mutations with the various phosphates, nitrates, carbonates, and acid gases, make it an active auxiliary in the assimilation of inorganic matter with plant growth, and gypsum thus becomes a potent factor in the development of vegetable life. Its abundance in Oklahoma soil, so different in appearance from silicate formations, is readily noticeable to the most casual observer. Much of it is near the surface, though it is diffused through the soil to great depth. In the red lands it is more prevalent than elsewhere, and it is proverbial that they stand

THE NAVAL CONTROL OF THE MEDITERRANEAN.

Two years ago a new fashion in diplomacy was inaugurated at Cronstadt. Before that year the mutual approximations of certain groups of the great powers were announced to the world by means of solemn meetings or festal interchanges of visits by their respective sovereigns. In 1891, however, it became necessary to inform all whom it might concern that Russia and France had resolved to make common cause. There was, however, one difficulty in making this announcement—a difficulty of etiquette. At the very outset of their *entente* the two powers were confronted, in a provoking way, by their essential incompatibility. The autocrat of all the Russias could obviously not pay a visit to the chief of the foremost democracy in Europe; on the other hand, the President of the French Republic dared not palter with the dignity of his country by being received in St. Petersburg with less than sovereign honor, or compromise the limited conception of his constitutional position by claiming for himself a treatment reserved for hereditary rulers. To add to the difficulty, the geographical situation of the two countries forbade any accidental meetings on the frontiers. What was to be done? The Triple Alliance had just been renewed with a perfect fanfare of jubilation in Berlin, Vienna, and Rome, and here were France and Russia agreed upon a retaliatory combination which they were unable to make public with suitable ceremony. In this dilemma the project of a naval demonstration at Cronstadt was adopted, and a French squadron, under Admiral Gervais, visited the Russian port, where they were entertained by the Czar with magnificent hospitality. The world, of course, at once understood the meaning of this interchange of courtesies, and the new method of instructing the public with regard to international relations became immediately fashionable. A rumor obtained currency to the effect that the new love of the French Republic meant a corresponding estrangement from Great Britain. Straightway, in order to correct this pernicious impression, another naval festivity was arranged, this time at Portsmouth. Lately we have had two more naval demonstrations—one at Toulon, the other at Taranto in Italy—and each has been intended to make some portentous announcement with regard to international relations.

It is amusing to notice that, although the objects and exact scope of these demonstrations are in no way ambiguous, their responsible devisers have testified a great deal of nervous anxiety lest their precise significance should be officially acknowledged. Thus the Russian visit to Toulon has been described as merely a courteous return for the French compliment paid to Cronstadt, while the simultaneous call of the British Mediterranean Squadron at Taranto and Spezzia has even been spoken of as an accidental coincidence. No one, however, is deceived by these *naive* pretences.



THE BRITISH WAR SHIP SANS PAREIL, ADMIRAL SIR M. CULME-SEYMOUR'S FLAGSHIP, ENTERING THE PORT AT TARANTO.

No one can possibly believe that British ministers are so clumsy as to permit Admiral Sir M. Culme-Seymour to pay an otherwise meaningless visit of courtesy to Italian waters at a time and under circumstances which were bound to invest it with the character of a manifestation of the views of Great Britain on an international compact which has come to affect her very nearly.

As a matter of fact, there is not a serious political student in Europe who does not regard the Taranto visit as a counter-demonstration to the Franco-Russian *fetes* at Toulon and Paris. And the reason is very simple. Since the visit of Admiral Gervais to Portsmouth, in 1891, it has become daily more apparent that the new attachment formed by France at Cronstadt is quite incompatible with a continuance of cordial relations with Great Britain on the old basis. In the first place, Russia is anxious to utilize her French allies for the promotion of the anti-British policy which she has much more at heart than her petulant quarrels with Germany, and in the second place France is not averse to playing into her ally's hands in this direction pending her great war of revenge with Germany, seeing that by this means she can make difficulties for Perfidious Albion in Egypt and acquire an extension of colonial possessions in Asia. Hence the Franco-Russian Alliance, originally formed to counterbalance the Triple Alliance, has developed into a very serious menace for this country, and the time may not be far distant when British statesmanship will have to take more specific account of it than is possible even by means of the new naval diplomacy.

This theory is not a fresh form of the Russophobe bogey of which Mr. Gladstone and the Duke of Argyll were wont to think and speak so scornfully some years

ago. Only last week a leading Russian newspaper, the *Novosti*, frankly stated that "the Franco-Russian Alliance is a guarantee of the political equilibrium, not only in Europe, but also in Asia, inasmuch as it enables the two powers to counterbalance British influence in Afghanistan and Siam." Of course we know what the Russian idea of "political equilibrium" in Asia means, and we have lately had a striking illustration on the Mekong of the Russification of the French in this respect. But the danger of the Franco-Russian Alliance with regard to ourselves is not altogether prospective. Already it has out-maneuvered us to our hurt. In Asia it has placed us between two fires, and we have now on the Burmese frontier a menace analogous to that which stares us in the face through the Hindoo Kush. In Europe it threatens our command of the Mediterranean, which is one of the conditions of the integrity of our empire. One eminent naval critic at least is of opinion that, when the Russians have a *pied a mer* in the Mediterranean, we shall have to play second fiddle in that sea to the Dual Alliance. This is, beyond question, a serious state of affairs, and it is scarcely sufficient to be assured—as we have been lately by means of the Taranto and Spezzia festivities—that the government is alive to the dangers of the situation. So much, however, is shown by the visit of the British Mediterranean Squadron to Italian waters, and by its enthusiastic reception by the Italian people, if the necessity should ever arise Great Britain would easily find means of defending herself in the present grouping of the powers. Is it, however, quite worth the while of France to make Englishmen contemplate even the possibility of ranging themselves with the Triple Alliance?—For the above and for our illustration we are indebted to *The Graphic*, London.

AMERICAN GRAIN ELEVATORS.*

By E. LEE HEIDENREICH, Member of Scandinavian Eng. Society of Chicago; Am. Inst. Min. Engrs.; Western Society of Engrs.

PREPARED FOR THE INTERNATIONAL ENGINEERING CONGRESS OF THE COLUMBIAN EXPOSITION, 1893.

THE handling of cereals on a vast continent naturally becomes a problem of not only national but universal prominence, and ever since the forties it has been considered one of the principal problems encountered by the commercial element of the United States. Realizing the importance of making a *resume* of the progress of construction of American grain elevators as short and concise as possible, owing to the large number of papers to be brought before this distinguished assembly, the writer will confine himself to a description of modern elevators merely, without touching upon the history of grain handling in America any more than is absolutely necessary.

The *modus operandi* of a grain elevator is about as follows:

1. A power car puller sets a string of cars each opposite an elevator leg, or vertical grain conveyor, located about a car length apart.

2. Car doors are opened, two shovelers enter each car and handle each a shovel operated by rope from a power shovel shaft in the elevator.

3. The grain drops into a receiving hopper, is elevated in buckets bolted to a rubber belt 150 ft. to the top floor of a cupola, where it is discharged in turning over a head pulley into an accumulator or garner, and thence into a weighing scale.

4. From the scale the grain is spouted:
   - *a.* On conveyor belts running horizontally and discharging over movable trippers into storage bins. (Storage elevators.)
   - *b.* In car spouts for reloading or transferring. (Railroad transfer elevators.)
   - *c.* Directly into storage bins.
     Into shipping bins with dock spouts, to be loaded into vessels.
     Into car spouts. (Terminal elevators for rapid handling and storage.)
   - *d.* Into garners above cleaning machinery. (Cleaning elevator.)

5. When the cars are empty the shovelers take with them the power shovels across the working floor (about 14 ft.) to a string of cars set in on the opposite side of the elevator, where the performance is repeated, while the first string of empty is being replaced by loaded cars.

In addition to the four classes of elevators mentioned, we have the marine elevators receiving grain in bulk from vessels—usually by means of one stationary and one movable marine leg—so as to unload two hatches simultaneously. The grain is elevated into a garner, weighed and re-elevated or spouted on conveyors into storage, or transferred into cars.

The sixth class of elevators are the small country houses or railroad station elevators, where grain is weighed in farmers' wagons and dumped into a pit, elevated, stored and for shipment re-elevated, weighed in a hopper scale and spouted into a car. The accompanying plates explain themselves, and, as there is nothing that can interest an engineer in their construction, no further reference will be made to them.

The Construction of Storage Elevators.—The want of additional storage at a railroad terminal is usually dictated by immediate demand, and for this reason this class of elevators is constructed usually with greater attention to cheapness and rapid completion, combined with strength, than to mechanical details. There have been cases where the problem has been put to an elevator builder in this way: "We want 3,000,000 bushels of storage, with a handling capacity of 200,000 bushels per day, constructed complete within 45 days; can you do it; and at what price?" If the builder says, "Yes; I can do it at 5 cents per bushel," the contract is signed and operations commenced at once. An excavation is made about 18 in. deep, if in clay or sand, and the same covered with hewn railroad ties in such manner as to get the entire surface as a basis for the superimposed load. Three or four timbers are laid side by side in bents from 11 to 14 ft. apart across the ground, and from 12 to 50 ft. longitudinally. Short cross corbels are rested thereon, supporting cross and longitudinal timbers, upon which the cribbing is spiked. The cribbing consists of pieces of 2 × 8 or 2 × 6 common pine or hemlock, usually surfaced one side and one edge, laid flat on the top of each other and spiked with 30d. spikes every 12 in., zigzag. The first two cross bents of the elevator are usually built on posts, so as to form a working floor from 20 to 28 ft. wide across the width of the elevator. Here are located the elevator legs or vertical grain conveyors, at a distance of from 36 to 40 ft. from center to center, according to the length of the freight cars. These legs extend into the ground about 12 ft. from the working floor, so as to be able to take grain from a receiving hopper, extending to a point between the rails of a track running alongside the front of the elevator as close as the cars will permit. The angle of the receiving hopper with the horizontal is in the neighborhood of 35°, or 2 to 3, so that the corners of the receiving hoppers will clean themselves of oats. The height of the planking in the rear or storage part varies considerably, according to the value of the building site, and runs from 40 to 85 ft. in height. Above the planking, *i. e.*, above the bin floor, a so-called cupola is erected directly over the space before designated as a working floor. In this cupola a series of scales for weighing the grain received or shipped is located, and inasmuch as, particularly in shipping, the elevator legs, receive grain all the time, it is usual to locate, immediately beneath the discharge spouts of the elevator legs, a garner or accumulator above each scale, for the purpose of receiving the grain while the scales are weighing and unloading. Another system of somewhat older date is to use two scales, called twin scales, for each elevator, accomplishing the same purpose. On the bin floor immediately beneath the scales and extending longitudinally with the elevator is a series of grain conveyors, consisting simply of endless belts varying in width from 16 to 40 in., on the upper line of which is located a so-called tripper, which is movable on a track running from one end of the elevator to the other. In receiving grain it is spouted down on said conveyors, and the tripper is located above the bin or reservoir in which the grain is to be stored. The speed of these belts in modern elevators is about 700 to 800 ft. per minute, and although the surface of the belt is perfectly flat, the cohesion between the kernels of grain is such as to gather the grain toward the center of the belt in such manner that from 2,000 to 20,000 bushels per hour can be conveyed. The bin bottoms in a storage elevator of this kind are usually flat, consisting of 3 × 14 joists, placed about 9 in. on centers, and covered with 2 × 6 dressed and matched flooring. Sometimes this floor is laid directly on the ties on sills, but this practice is not to be recommended, as it leaves less chance for ventilation. For unloading the grain from the elevator, belt conveyors are located along the bin bottoms at convenient distances, so as to reach the front receiving or shipping legs, and are covered with planking or cribbing, or planking on the sides with timbers overhead, in such manner as to form tunnels extending from the working floor to the end of the elevator.

In receiving grain from the cars, a train consisting of as many cars as there are receiving legs is detached by means of a power car puller from a string of from twenty to thirty cars sent in by a switch engine. Owing to the different lengths of the cars, they are detached and "spotted" or located each opposite a receiving leg. The exterior covering of a storage elevator is usually of corrugated iron, with a tin or aluminum alloy roof.

Inasmuch as the elevator legs must extend some 8 or 10 ft. into the ground, they are located in steel tanks of $\frac{1}{4}$ to $\frac{5}{16}$ material, and, to prevent the collapse of these by the pressure from the superstructure, it is a good practice to drive a few piles on each side of each tank and cap them with timber in such a manner as to bridge the tanks.

As for the time, the principal item in rapid construction of this kind is to get the material on the ground. The planking or cribbing can be done at the rate of 6 to 7 ft. a day; so the main structure, from the top of foundation to the bin floor, can be finished in 12 to 15 working days, when properly managed.

Where the bins or grain reservoirs are more than 12 × 16 ft. area, they should be rodded. A good rule for calculating the rodding of a bin is to imagine a bin filled with grain, turned over flat and the side suspended by rods running through the grain. As the rods should not exceed $\frac{3}{4}$ in. or $\frac{7}{8}$ in. diameter steel, it gives a space between the rods in large bins of about 5 ft. square. Formerly the practice was to increase the diameter of the rods toward the bottom of the bin, but it has been proved that the horizontal pressure in a bin is practically constant from within 15 ft. of the top to the bottom. The reason for this is that grain such as corn, wheat and oats in bulk forms a peculiar bridging, leaving the pressure on the bottom, under ordinary circumstances, constant for any height above twice the width of the bin.

Experiments have given the load on an equilateral bin bottom as very nearly equal to the weight of a paraboloid of a height 1·8 times its base, and this fact led the writer to make the bin rods the same diameter from bottom to top of bin, with good results.

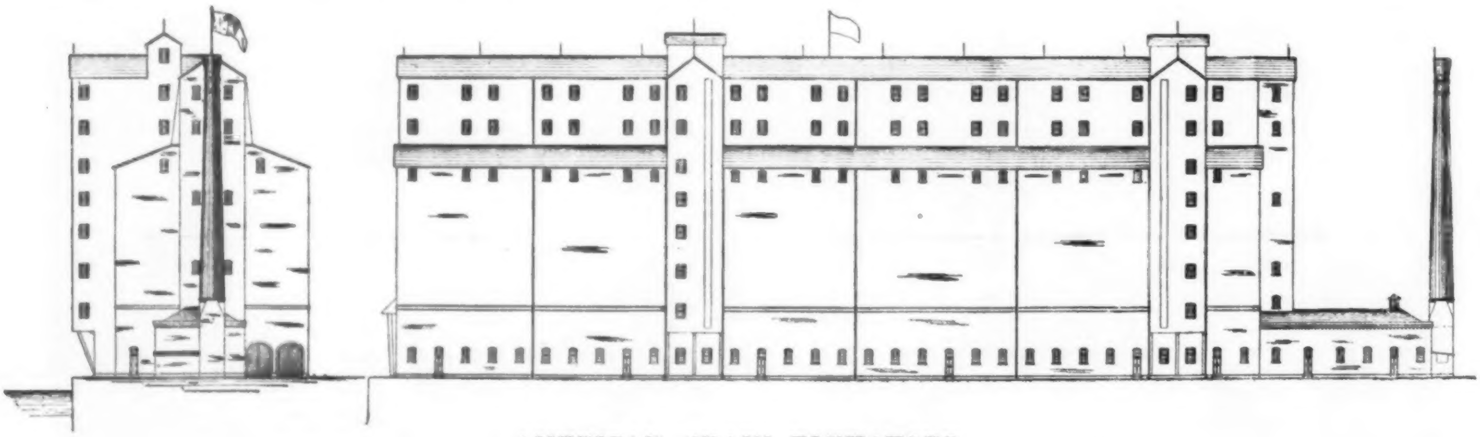
In some of the older elevators, where the bin rods at the bottom were from $1\frac{1}{2}$ to 2 in. diameter, it has been found that the down draught of the grain in unloading the bin bent the rods and pulled the washers into the bin walls, while the $\frac{5}{8}$ to $\frac{7}{8}$ in. rod seems to cut through this suction without damage. But for this peculiarity of grain, the construction of bin bottoms would present great difficulties, the static load figuring up to 4,000 lb. per square foot.

Railroad Transfer Elevators.—The second class of elevators are the railroad transfer elevators. Some State legislatures have during the past few years passed acts compelling railroads to give hopper scale weights on transferred grain, and as a result a number of transfer houses have been built, handling from 100 to 300 cars per day. Their construction presents few difficulties, as they have no storage capacity whatever.

Two tracks run entirely through the building, the elevator machinery being placed in the platform space between the tracks. The cupola, with the elevator heads and scales, is located exactly above the first floor, at a height to give sufficient fall, through car spouts, to trim or fill the cars without the use of manual labor in the cars.

Terminal Elevators.—The third class of elevators refers to terminal houses for storage, rapid handling and shipping, either by lake and rail or both. In general, these houses are termed "up houses," *i. e.*, they are entirely built on posts, in such manner as to form a large working floor beneath the entire storage area. From three to four railroad tracks are run through the entire length of the house, and, according to the number of cars the house can unload simultaneously, they are termed 5-car, 8-car, 10-car houses, etc. The most modern construction locates all receiving and shipping elevators in one line, with receiving tracks on each side, thus occupying the three center bents of the elevator. The loading tracks are usually located in the outside bents, while, of course, the center tracks are arranged for shipping purposes. Owing to the size of the car, the transverse bents in the house are at least 13 to 14 ft. each, which makes the house either 56, 70, 84 or 98 ft. wide. Longitudinally the bents usually are in succession, 12, 12 and 14 ft., leaving the elevator legs at a distance of 38 ft. from centers. At the end of the elevator the power house is located, in such manner that one of the loading tracks passing through the house also passes the engine house, so that coal may be received from one end while grain is loaded into cars going in an opposite direction. All bin bottoms in a house of this description are hopper bottoms, and all bin openings of a diameter sufficient to fill elevator legs or conveyors to their full capacity.

A modern rapid working terminal elevator is equipped with the very best machinery, electric lights, fire pump and service, passenger elevator, dust collectors and floor sweepers—in short, all contrivances that will cheapen or lessen labor and promote rapid handling of the grain. As the entire building rests on posts, the loads are concentrated at certain points. The load per pier varies from 300 to 450 tons, and as the safe bearing capacity of the soil seldom exceeds $2\frac{1}{2}$ to 3 tons, piling is resorted to, with cross and longitudinal oak grillage and stone piers. As the entire load of grain is thrown on the bin walls, the girders supporting these walls between the clusters of posts must be of a very strong construction, usually two 12 × 14 long leaf yellow pine or oak sticks, on top of each other, supported by white oak corbels braced back into the



AMERICAN GRAIN ELEVATORS.

* From the Transactions of the American Society of Civil Engineers.

posts below. Formerly the entire basement was taken up by stone piers and elevator tanks, but the tendency is now toward using less stone and extending the posts into the basement, leaving it open and concreted smoothly, so as to enable the removal of the dust and the admission of light below the first floor. Fireproof construction of the first floor and basement is much to be recommended, although it materially increases the cost of the elevator.

Cleaning Elevators.—Under the head of cleaning elevators we encounter the most complicated construction and the greatest variety of details. The writer will, however, confine himself to what has been adjudged the most improved arrangement.

The receiving department of a first-class cleaning elevator is practically that of an up-house or handling house, as may be seen by referring to the accompanying sketch. Between the first and bin floors is, however, inserted a cleaning floor, a separate department with garners above and garners beneath. In this manner the grain from the scales is spouted into the garners; thence, by gravity, through the cleaners into the lower bins, whence it is elevated and spouted into storage, shipping bins or car spouts. By enabling a number of small bins overhead and below the cleaning floor to communicate with the cleaners, it can readily be seen that any mixing or grading can be done without difficulty.

If cleaners are located on first floor or bin floor, elevator legs are required for either taking away from or supplying the cleaners, and as the capacity of a leg is 5,000 to 6,000 bushels per hour, while a cleaner only averages 2,000 and an oat clipper 500 bushels, it is clear that there is a waste of machinery in this arrangement.

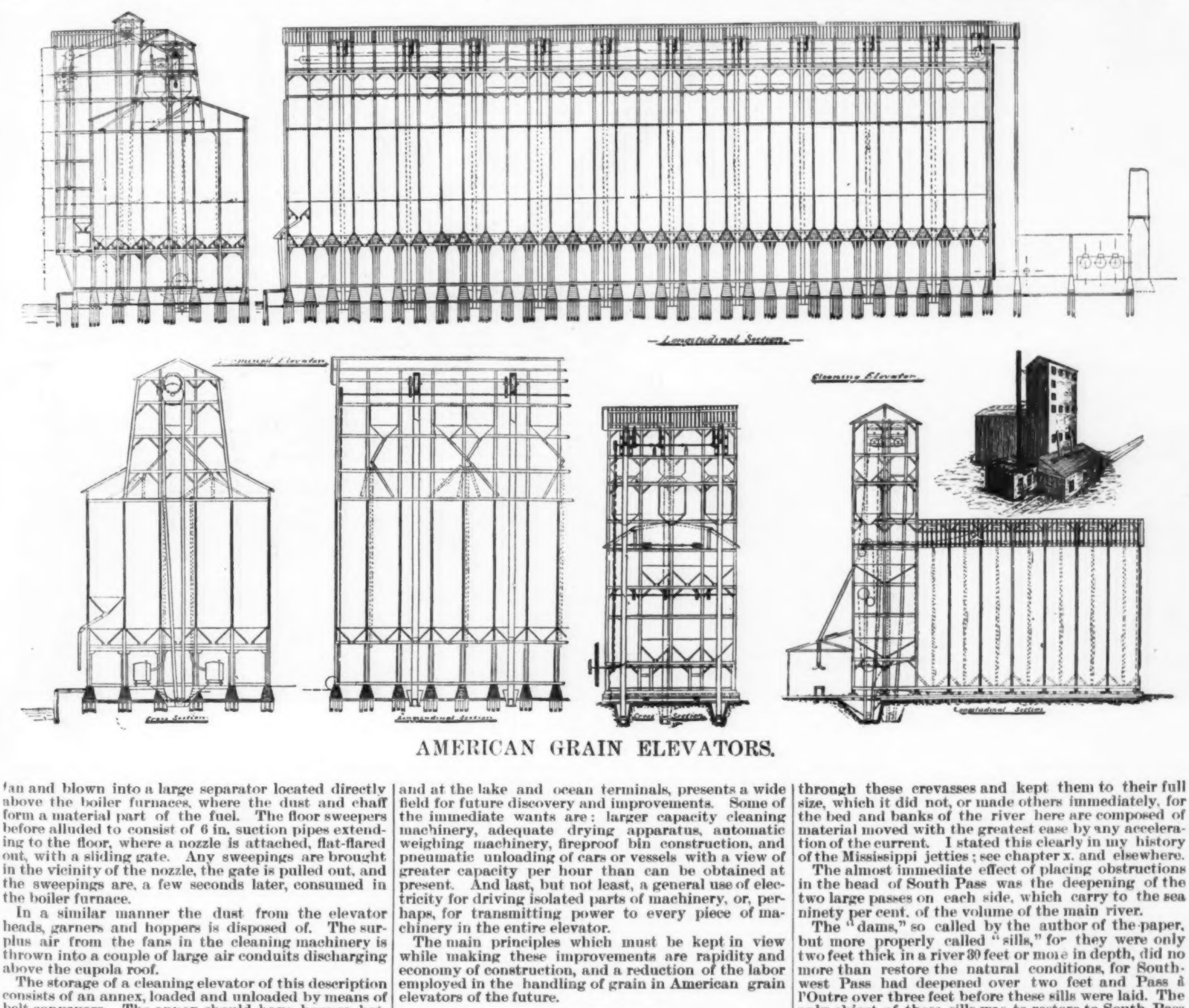
The dust from the cleaning machinery is blown into separators or cyclones, and exhausted by a powerful years. The most approved method to-day is a high speed engine with manila rope transmission from the engine to the last piece of machinery in the elevator. In a cleaning house the cleaner shaft should run about 250 revolutions per minute, as the cleaning machinery runs at a speed from 400 to 550 revolutions per minute, and the engine from 100 to 150 revolutions per minute. A direct rope transmission from a main line shaft in the cupola to each of the elevator head pulleys is found to give satisfaction. The usual practice is to have eight strands of 1-in. rope for each transmission, the rope speed being only about 750 ft. per minute. It is very important that all the machinery in an elevator be strictly first class in every respect, as any hitch or slip in the driving gear is sure to cause serious chokings of the grain where it enters the elevator leg.

Grain elevators are usually covered with either brick or iron; in case of brick the unevenness in the settling between the exterior brick shell and the main structure is taken care of by means of anchors with slip joints, permitting the planking to go down 12 to 24 in. without disturbing the tie between both parts. In case of corrugated iron covering, the sheets are put on with corrugations running vertically, and nailed 4 in. from the lower edge only, so that the shrinkage of the planking is taken care of separately for each sheet.

The best roofs are probably [illegible] C. old process charcoal tin, although last year a large cleaning elevator was built with a roof of aluminum alloy metal, greatly reducing the weight and having the advantage of not requiring painting.

The principal requirements of a grain elevator, namely, strength, tightness, light and effective and accessible machinery, are such as to invite the attention of engineers; and before closing the writer wishes to say that the handling and storing of grain, both in the interior and at the lake and ocean terminals, presents a wide field for future discovery and improvements. Some of the immediate wants are: larger capacity cleaning machinery, adequate drying apparatus, automatic weighing machinery, fireproof bin construction, and pneumatic unloading of cars or vessels with a view of greater capacity per hour than can be obtained at present. And last, but not least, a general use of electricity for driving isolated parts of machinery, or, perhaps, for transmitting power to every piece of machinery in the entire elevator.

The main principles which must be kept in view while making these improvements are rapidity and economy of construction, and a reduction of the labor employed in the handling of grain in American grain elevators of the future.



AMERICAN GRAIN ELEVATORS.

fan and blown into a large separator located directly above the boiler furnaces, where the dust and chaff form a material part of the fuel. The floor sweepers before alluded to consist of 6 in. suction pipes extending to the floor, where a nozzle is attached, flat-flared out, with a sliding gate. Any sweepings are brought in the vicinity of the nozzle, the gate is pulled out, and the sweepings are, a few seconds later, consumed in the boiler furnace.

In a similar manner the dust from the elevator heads, garners and hoppers is disposed of. The surplus air from the fans in the cleaning machinery is thrown into a couple of large air conduits discharging above the cupola roof.

The storage of a cleaning elevator of this description consists of an annex, loaded and unloaded by means of belt conveyors. The annex should have hopper bottoms, and is shown in the accompanying plate built on ties, while the front or cleaning part is built on piles. Owing to a certain shrinkage in the planking, or cribbing, many difficulties are often met where an up-house joins a low annex, as while the posts in the former retain their length, the planking in the low annex shrinks several inches in the same height. This is usually remedied by giving the cross timbers running into the annex a corresponding camber, so that when the house has settled it will be nearly level.

Some builders erect the entire cupola of any elevator on independent posts extending through the bins, to counteract any influence of the shrinkage on the driving machinery, but the writer's experience is that the cribbing shrinks so evenly that no material trouble occurs on this score, so that he considers it advisable to build the cupola directly on the cribbing.

As to the driving machinery in grain elevators, it has changed materially during the past six or eight

THE JETTY WORKS AT THE MOUTH OF THE MISSISSIPPI RIVER.

To the Editor of the Scientific American:

In your issue of November 11 is an article on "The Mississippi River," by William L. Elseffer, C.E.

I do not intend to go into the details of the discussion at this time, as these, so far as the river above New Orleans is concerned, can be better stated by some one representing the Mississippi River Commission, which has charge of the work.

I wish to take issue now only with one or two statements of the author of the paper. He stated as follows:

"Here then is presented this most anomalous condition: a dangerous flood beginning in the Mississippi below, near its mouth, while yet no dangerous flood has appeared at any station elsewhere in the river or in any great tributary. There was no natural cause for this unprecedented and dangerous high water. The condition was artificial; it was imposed upon the river by experimental and unscientific constructions. It was the refluence of waters, caused by the jetties in the mouths of the Mississippi and by the spur dikes in the channel at New Orleans. No other cause can be found under the heavens for the dangerous high water condition at New Orleans on April 5, 1892."

From an intimate knowledge of the condition for nearly twenty years, having had charge as resident engineer of the works in the Mississippi at its South Pass outlet, I can state positively that these works have had no effect whatever upon the flood height of the river at and above New Orleans, or, in fact, between New Orleans and the Head of the Passes, 100 miles distant from that city.

I am equally confident that the spur dikes placed in the river at and near New Orleans have had no effect upon the flood height.

The top of the maximum flood at New Orleans is about 17 feet above mean Gulf level found at the mouth of the Passes, about 115 miles below New Orleans. This mean Gulf level is scarcely two feet below the level of the narrow ridge of land along the immediate banks of the river in its lower reaches, and is about the level of the mud flats just back of this narrow river ridge of deposits. There are two free outlets within a short distance above the Head of the Passes; one, "Cubits" crevasse, three miles only above these "dams" spoken of in the article, which, at the time of building them, was half a mile wide and 60 feet deep. The former was in recent years nearly as large.

If the "dams" had raised the water to any appreciable extent and prevented its free flow to the sea by the three passes, it would have at once sought relief through these crevasses and kept them to their full size, which it did not, or made others immediately, for the bed and banks of the river here are composed of material moved with the greatest ease by any acceleration of the current. I stated this clearly in my history of the Mississippi jetties; see chapter x. and elsewhere.

The almost immediate effect of placing obstructions in the head of South Pass was the deepening of the two large passes on each side, which carry to the sea ninety per cent. of the volume of the main river.

The "dams," so called by the author of the paper, but more properly called "sills," for they were only two feet thick in a river 30 feet or more in depth, did no more than restore the natural conditions, for Southwest Pass had deepened over two feet and Pass à l'Outre over three feet before these sills were laid. The only object of these sills was to restore to South Pass the volume of which it had been depleted by the dikes that had been built in the head of this little pass.

The above details are given to show how unreasonable is the statement quoted from the article we are reviewing.

From examinations, levels, and continuous study of the abstruse hydraulic problems involved at this point, I can asert that no results whatever in raising the river one inch at New Orleans have ever proceeded from any of the works at any time placed in the passes of the Mississippi River.

And the author is equally in error in treating of the proposed improvement in the Southwest Pass, which Capt. Eads so earnestly desired to improve that his disappointment is not being able to do so was one of the keenest of his life.

All that the company, which is organized for this purpose, desires is that the natural, normal volume of this pass be given it. This the pass now has and will

be likely to have, and we are confident that the "sill" built across it by Capt. Eads does not divert from it any of the normal volume to which it is entitled. We intend only to build works in the mouth of this pass, in the Gulf of Mexico, and we believe that this is all that is required to give a permanent channel of much greater dimensions in width and depth than it is possible to make in the little pass. E. L. CORTHELL,

Pres. Southwest Pass Imp. Co.

71 Broadway, New York City, Nov. 23, 1893.

THE NORTH SEA-BALTIC CANAL.

ONE of the greatest marine engineering achievements of the present century will, undoubtedly, be the canal which is to connect the North Sea and the Baltic, and which is now approaching completion. From an engineering point of view, the work exceeds that of the Suez, Corinth and Manchester Canals, and the commercial and strategic importance of the new waterway can only compare with those of the first mentioned. Truly, the North Sea-Baltic Canal is styled the "Suez Canal" of Europe, and it is *en passant* curious that this great work, tending to the "solidification" of Germany, was conceived by Prince Bismarck, and commenced by him in spite of all the opposition of Moltke and a host of other famous strategists, who argued that the canal would require an army corps for its protection, and on that ground was undesirable. And now, just as the Bismarck sand glass appears to be running out, this great monument of his foresight and of German engineering skill is rapidly nearing its completion, as the engineers of the canal assured H.M. the German Emperor, on his recent visit to the works, that it should be opened, without fail, next year, *i. e.*, seven years curves having radii not under 3,000 yards. Only some small curves have a radius of 1,000 yards, and 63 per cent. of the line of the canal is practically straight.

At Holtenau the great locks are already in full working order. The basins are 150 yards in length and 25 yards in breadth. In order to render the building pit dry, the energetic course has been taken of attacking the land water trickling down toward the same above it by sinking wells and using steam pumps. Thus the water-carrying layer is drained before it is laid bare in the bottom excavations for the sluice structures. The latter, by the way, are principally built of bricks, while cement work with admixture of lime is also largely employed in the construction, whereby a more plastic mortar is obtained, and whereby, too, the brickwork is said to become more compact. The mixture of the mortar is effected in pug mills with vertical rollers. This process is most interesting to structural engineers, and deserves a fuller description than we can give now.

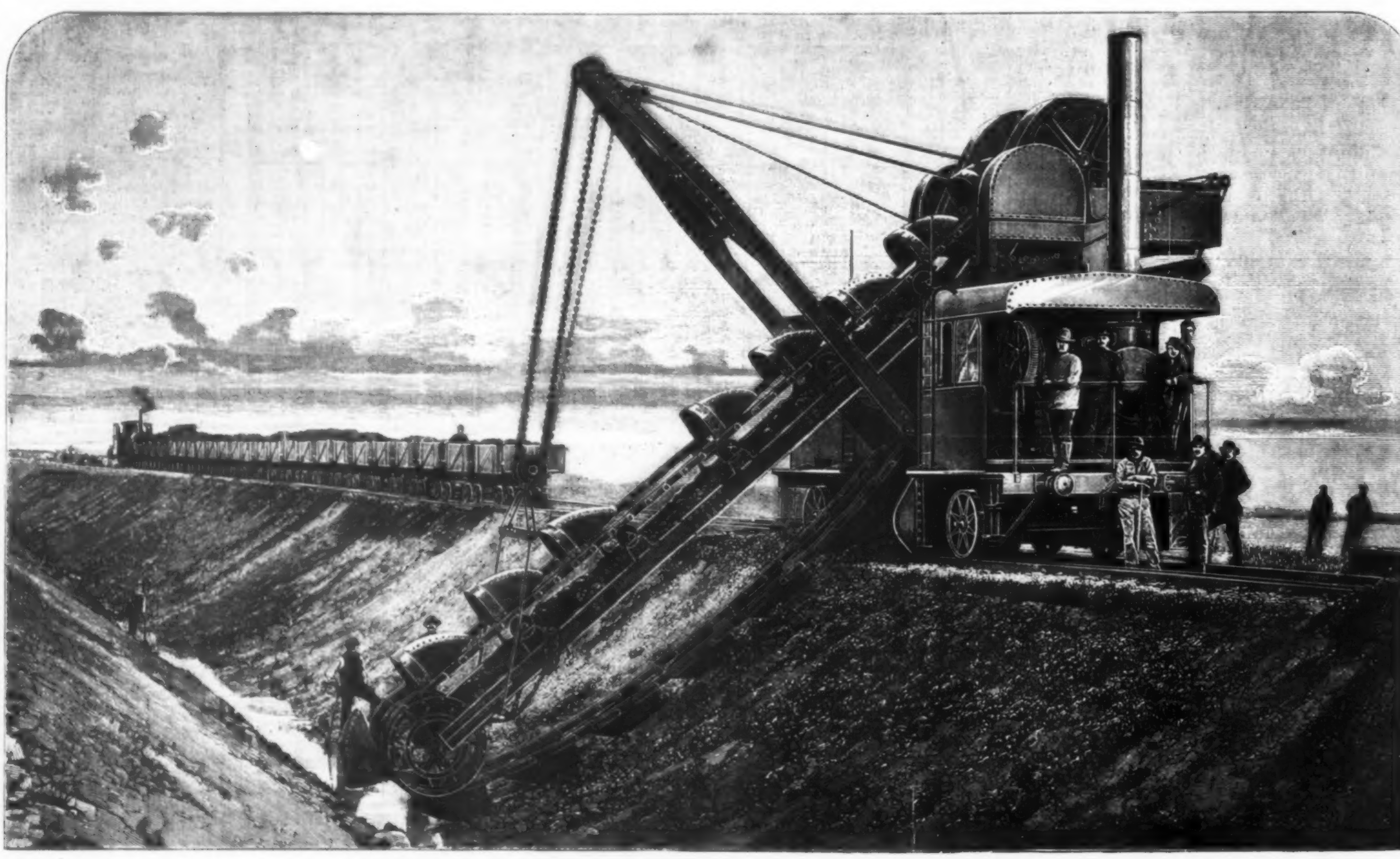
From Holtenau the canal is already navigable for steam launches in part by the old Eider Canal, but several of the most interesting engineering sections should be inspected on foot. Everywhere the great dredgers and excavators, Hollanders or Dutchmen, as they are called through their origin, meet the eye, and of one of these at work we give an illustration. The material raised is either emptied into barges, *i. e.*, where there is now water, or shot into railway trucks. All along the works the great importance of the steam engine and machinery is apparent. Huge brickworks have been established especially for the supply of the canal by the well-known firm of Philip Holzmann & Co., Frankfort-on-the-Main, and called the Rosenkrantz Brickworks. Bricks are used not only for the

During the summer some 5,000 men have been at work on the canal, one-half of whom live in barracks erected by the canal authorities, where they are excellently treated and housed. There are about 12 such barracks along the canal, besides 3 hospitals for 60 men. The construction of the sluices at each end has been assigned to a Dutch firm of *entrepreneurs*. The wages on the works run rather high for Germany, viz., from 2s. 9d. to 3s. for ordinary laborers per diem, and from 4s. to 6s. a day for piecework. Foremen, inspectors and enginemen receive upward of 10s. a day. A large number of the men are Swiss and Italian, these nationalities being preferred to German on account of their sober habits and by their giving less trouble than the natives. In autumn and winter, of course, the number of men is greatly reduced. Up to the present nearly 80,000,000 cubic meters of earth, etc., have been excavated and shifted at a cost of some £3,500,000. The construction is carried out by a maritime board under the immediate supervision of Geheimebaurath Fulcher, who has under him four sectional engineers, *i. e.*, at Kiel, Holtenau, Rendsburg and Grunthal, whose assistants, of course, are legion. The entire cost of the North Sea-Baltic Canal is estimated at £7,800,000, of which Prussia contributes £2,500,000 and the empire the balance.—*The Engineer.*

Further description and illustrations of this great work will be found in SUPPLEMENT No. 810.

CURIOUS BEVEL WHEELS.

A MECHANICAL curiosity was exhibited in the Machinery Hall, Chicago, by the Belgram Gear Company, in the shape of three different sized bevel wheels, all gearing perfectly with a fourth. The smallest of the



STEAM EXCAVATOR, NORTH SEA SHIP CANAL.

after the turning of the first sod, as contemplated by the Iron Chancellor.

Approaching the canal works from Kiel, near its Baltic mouth, we enter it at Holtenau, also in the Kieler Fjord, and exactly in the same spot where was the mouth of the so-called "Eider" Canal, taking its name from that river, and which the new canal partly follows in its course. The canal finishes in the river Elbe, at Brunsbuttel, the length from mouth to mouth being exactly 60 miles.

The Baltic Canal is, in reality, a sectional cutting through the province of Holstein, there being no locks or sluices all along its course, but only at each end. Here there is a double set of gates in each place, in order to meet any eventuality of tide on both sides, and which thus regulate the water level in the bed. The average level of the water in the canal will be the same as that of the Baltic, inasmuch as the sluices at Holtenau are generally to be kept open, and are only to be closed when the tide in that sea rises or falls half a fathom over or below the normal tide, and eventually calculated to happen on five-and-twenty days of the year. But at the Elbe entrance, on the other hand, where the tidal waters play an important part, the gates will only remain open for three or four hours on each tide. The bed of the canal lies nine fathoms below the normal water level, and it has a width at the bottom of 22 yards. The sides—two yards below the surface—slope from 2 to 12 yards. From the banquette down to the bottom the sides are inclined at the top 1 to 2 and at the bottom 1 to 3. With this profile the depth of water on lowest tide is 6·17 yards, with a width of 36 yards, so that this would enable almost all Baltic trading steamers, which generally draw no more than 18 feet of water, with a 36-foot beam, to pass each other easily.

The line of the canal is very regular, all the greater locks and bridges, but also for securing the slopes in the water lines; so, of course, the demand is enormous.

The canal is also connected by skillfully constructed locks with the Lower Eider, and another highly interesting point are the swing bridges with their foundations of the Flensburg-Neumunster Railway crossing the canal. The fundamental works of the foundations have been carried out by the aid of compressed air, and electricity is used as motive power for the work inside the air bell. For a considerable distance the Eider runs parallel with the canal, and in this section shoots for the transport of the excavated materials are largely resorted to for their conveyance to the banks, dams or other places. The transport is effected partly through open shoots, which are supported by the dredger or elevator itself, and partly through closed, sometimes floating, shoots or conductors, in which the *debris*, having been sifted in a special apparatus, is pumped up by the aid of centrifugal pumps.

At Grunthal, the canal passes the watershed between the Elbe and the Eider, and here the engineering works have been very great. A gigantic cutting has been made for the waterway, and a railway and road embankment with a bridge constructed, the latter being 130 feet in height above the water surface, and thus enabling the largest vessels to pass freely under it, while it has a span of 470 feet. Across this embankment runs the main railway from Neumunster to Heide connecting the south and north of Holstein with the rest of Prussia. The stone used for the locks, etc., comes from the quarries at Neissen, in Saxony, and the blocks are conveyed in lighters down the Elbe to Hamburg, where they are reloaded in ships and sent on to Brunsbuttel. Stone will also be used for the construction of the breakwaters, which are to protect the entrances, as well as for the lighthouses at each end. The old Eider Canal is now closed for traffic.

three bevel wheels is apparently about half the diameter of the largest of the three; nevertheless, all the wheels work quite smoothly and correctly. The possibility of such an arrangement was, we believe, first pointed out by Mr. W. J. Last, A.M.I.C.E., in a paper published some years back in the Minutes of the Proceedings of the Institution of Civil Engineers. The explanation of the apparent anomaly is that each of the smaller wheels rolls on a different pitch line on the main wheel, and the teeth of each are specially formed to suit its own pitch cone.

IMPROVED METHOD OF CONSTRUCTING FOUNDATIONS UNDER WATER BY FORCING CEMENT INTO LOOSE SAND OR GRAVEL BY MEANS OF AIR PRESSURE.*

By FR. NEUKIRCH, C.E., of Bremen, Germany.

PREPARED FOR THE INTERNATIONAL ENGINEERING CONGRESS OF THE COLUMBIAN EXPOSITION, 1893.

THIS improved method of constructing foundations has for its object to convert the sand or gravel, existing under water at the locality where the foundations are to be made, into a solid body in the form of sand or gravel concrete. This conversion is effected *in situ*, so that no excavation to the solid bottom is required. The sand is converted into sand concrete by forcing cement in the form of powder, as it occurs in commerce, through a pipe by air pressure into the submerged sand. The pipe has an internal diameter of about 1½ in., and is drawn to a point at the lower end, in which there are three or more holes of about ⅜ in. diameter. The upper end is connected by a bend and rubber tubing

* From the Transactions of the American Society of Civil Engineers.

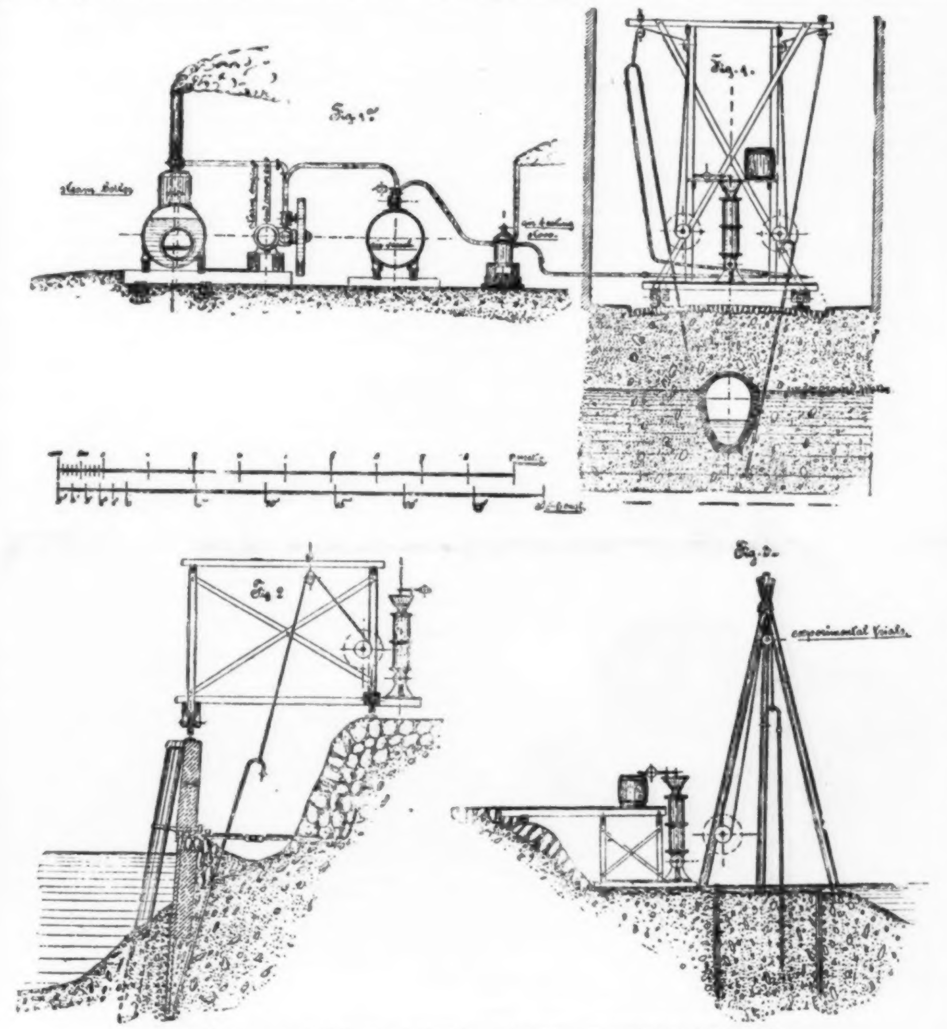
with the air pressure supply pipe in such manner that the pipe can be raised, lowered, and moved while the air pressure is flowing through it.

In the air pressure supply pipe, provision is made by means of suitable branches and stop cocks for connecting therewith an apparatus which by means of an injector device enables any desired quantity of cement powder to be fed into the air current. The air pressure, together with the cement powder, issues through the small openings at the lower end of the lance pipe, and is driven with considerable pressure into the sand foundation; this is very mobile, as it is entirely under water, and consequently the blowing in of the cement produces a motion in the foundation pit similar to that in a vessel of boiling water, the steam bubbles instead of air bubbles being formed. The cement carried by the air is retained by the wet sand and combines with this to form sand concrete.

By the boiling motion an intimate mixture of the wet sand with the cement is effected.

After the injection of air has ceased, the grains of sand in subsiding adhere very firmly together, and experiments have shown that a natural bed of sand, after having one-fifth of its volume of cement injected into it, will after the operation occupy a smaller space than before; this was shown by the fact that the surface of the sand concrete lay deeper than that of the surrounding natural sand bed.

The introduction of the lance tube into the sand bed is effected by first blowing air through it, so that the air issuing from the lower end forces back the sand, and in setting it in motion renders the sinking of the



FORCING CEMENT INTO SAND FOUNDATIONS.

tube to considerable depths, such as 16 to 19 ft., readily possible in a comparatively short space of time; this operation is rather more difficult only when the bed is not purely sand, but contains larger stones, wood, etc. In this case it may be necessary to raise the tube up again and to insert it at a different place, so as to avoid the obstructions.

In order to insure a uniform mixture in the foundation pit, it is divided into small fields of from 8 to 12 in. square, and into each of these the required quantity of cement, which is ascertained by dividing the cubic contents of the field by the required proportion of the admixture, is blown. The lance tube is first sunk in each field down the solid substratum by means of air pressure alone; when it has attained this depth, cement is supplied to the air current, and during the continued introduction of the cement powder the tube is slowly drawn upward until the required quantity of cement has been introduced.

In order to enable the lance tube to be readily handled, it is suspended from a tripod or traveling stage having a small winch by means of which the tube can be readily raised and lowered. The movable stage has the advantage that it enables every field of the foundation pit to be easily reached. The steam boiler and compressor for producing the air pressure can be placed at a greater distance from the foundation pit; the air pressure can readily be conducted through wrought iron pipes to the point required. It is of advantage to warm the air in the vicinity of the cement apparatus, as otherwise moisture might be separated by the cooling of the air, which would be very inconvenient in working and easily produce a clogging of the cocks and injector nozzles.

For warming the air a small cast iron stove is employed, consisting of two cylinders inserted one within the other and connected together air-tight. In the inner cylinder is a fire grate on which a light fire is maintained. The air pressure is made to circulate through the annular space between the two cylinders. The inner cylinder has external ribs formed on it, so that the air pressure is brought in contact with a considerable heating surface on its way through.

The steam boiler and compressor can be arranged as a portable engine, so as to enable the apparatus to be readily transported from one foundation pit to another.

This method of constructing foundations may be compared with the ordinary method of making concrete foundations, in a similar manner as the Bessemer process compares with the puddling process in the manufacture of iron. In the Bessemer process the blowing of air into the molten pig iron causes the carbon to be burned and a solid metal steel is produced, while in the puddling process this conversion is effected only by laborious stirring. In the new process of making foundations the blowing of the cement into the stratum of liquid sand, as it were, converts it into a solid body, while up to the present time this was also only effected by laborious stirring.

As the entire process is mainly carried out by machinery and requires only a small amount of manual labor, foundations can be carried on rapidly by this process.

If it be desired to transmit the pressure which the foundations have to bear to a substratum below that upon which the sandbed lies, this can be effected by driving in piles to the required depth before the cementing process is commenced. These piles will then be completely embedded in the sand concrete and be firmly united therewith, so that they may be considered as part of the structure.

If it be desired to sharply limit the lateral dimensions of the body of sand concrete, or to protect it against external influences, the foundation pit is in the first instance surrounded by a coffer dam.

The hardening of the sand concrete formed as above described takes several weeks, and the complete hardening several months, as in the case of ordinary concrete under water.

On the accompanying drawing is shown the necessary plant for carrying out the above described process, as also the application thereof for some cases.

Fig. 1*a* shows the arrangement of the steam boiler, compressor, air reservoir and heating stove for the air pressure supply, which should always be situated near the place of operation. Fig. 1 shows the application of the process for consolidating the soil round a brick sewer so as to insure its being water-tight against the surrounding aqueous sand stratum, and to afford it a rigid bed therein.

The sewer, which is 5 ft. internal height, lies in quicksand, and had become so leaky that the sand penetrated into it in considerable quantity. Owing to this, the road pavement and also the neighboring houses subsided, so that it became urgently necessary to provide a remedy. This could not readily be done in the usual manner, as it appeared very hazardous to drive coffer dams in the somewhat narrow street. By applying the above described invention the sewer was made perfectly tight and secure for a length of about 500 ft.

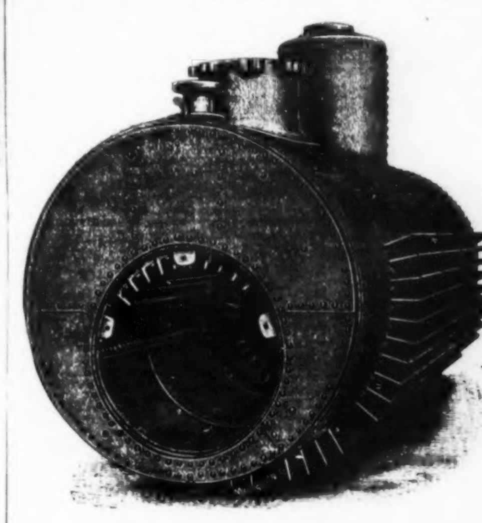
Fig. 2 shows an application of the process in the harbor of Vegesack, near Bremen. For the quay wall a bulkhead of rolled iron was used. Wood could not be used for this purpose, because the bed is very stony, and because in consequence of the ebb and flood the dam is not always altogether under water. Such iron dams are with difficulty made completely tight. By blowing in cement behind the dam, it was rendered perfectly tight and safe.

Fig. 3 shows the arrangement employed for experiments.

A simple tripod is in this case erected for suspending the lance tube, while in the previously described arrangements a movable frame was employed.

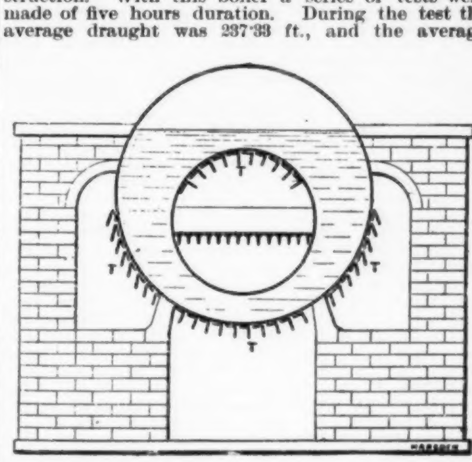
IMPROVEMENT IN BOILER CONSTRUCTION.

THE accompanying illustrations show a novel improvement in boiler construction, introduced by the "Advance" Boiler Co., Limited, of St. Mary's



IMPROVED BOILER.

Gate, Manchester, for promoting and increasing evaporation. The improvement, which is applicable to land or marine boilers, secures a greatly increased evaporative efficiency without introducing any complicated parts. The system consists of a simple arrangement of angle irons, riveted longitudinally on to the inside of the furnace flue and on the outside of the boiler shell in the side flues, the function of these angle irons being to arrest and absorb the heat and transmit it to the water. A test boiler, of the Cornish type, 15 ft. long by 5 ft. diameter, has been constructed on the above system. On this boiler there are ten 3 in. by ⅜ in. angle irons riveted on to the first and second plates in the tube over the fire grate. Beyond the bridge, the angle irons are 3 in. by 5 in. by ⅜ in., and are riveted around the flue, the 5 in. part of the angle iron being presented to the flames and forming the rib, or heat absorber. On the outside of the shell the angles are 3 in. by 6 in. by ⅜ in., with the 6 in. part radiating from the shell into the side and bottom flues. Beyond these additions the boiler has in no way been altered from the plain Cornish construction. With this boiler a series of tests were made of five hours duration. During the test the average draught was 237·33 ft., and the average



temperature of the feed water was 57·25 deg. Fah., and that of the gases, 772·50 deg. Fah., the average temperature of the atmosphere being 64 deg. Fah. The coal consumed was 5 cwt., less 40 lb. of ashes, or 520 lb. of fuel, and the water evaporated was 4.730 lb. With the boiler in its normal condition as a simple Cornish boiler, and before any angle irons were affixed, the evaporation was 4·67 lb. of water per lb. of coal. The results of the test made showed an improvement of nearly 100 per cent. in the evaporative power of the boiler upon its former self. Besides the advantages secured as shown by the tests, other collateral advantages claimed for this system are that not only do the angle irons arrest the heat and transmit it to the water, but they form channels along which the flames sweep in close contact with the boiler, in this respect also increasing its efficiency while the boiler is materially strengthened by the addition of the angle irons, which form a series of longitudinal ribs external to the flue and shell. Reports have been obtained from several leading engineers who are authorities on boiler construction, and all of these are of a most satisfactory character, as to the very greatly increased

efficiency obtained by the very simple arrangement of angle irons riveted longitudinally on the inside of the furnace flue and on the outside of the boiler shell. Among the advantages claimed by the company for this new system of boiler construction is that the arrangement of angle irons has the effect of arresting and conducting to the water a large percentage of the waste heat, thus insuring great economy in fuel, while improved draught, reduced fire grate area, with increased combustion per foot of grate area, and increased durability of the boiler are also secured. It is also claimed that the boiler is practically smokeless, and that there is less incrustation by reason of the increased circulation of the water.—*Marine Engineer.*

FUNDAMENTAL STANDARDS OF LENGTH AND MASS.*

While the Constitution of the United States authorizes Congress to "fix the standard of weights and measures," this power has never been definitely exercised, and but little legislation has been enacted upon the subject. Washington regarded the matter of sufficient importance to justify a special reference to it in his first annual message to Congress (January, 1790), and Jefferson, while Secretary of State, prepared a report at the request of the House of Representatives, in which he proposed (July, 1790) "to reduce every branch to the decimal ratio already established for coins, and thus bring the calculation of the principal affairs of life within the arithmetic of every man who can multiply and divide." The consideration of the subject being again urged by Washington, a committee of Congress reported in favor of Jefferson's plan, but no legislation followed. In the meantime the executive branch of the government found it necessary to procure standards for use in the collection of revenue and other operations in which weights and measures were required, and the Troughton 82 in. brass scale was obtained for the Coast and Geodetic Survey in 1814, a platinum kilogramme and meter, by Gallatin, in 1821, and a troy pound from London in 1827, also by Gallatin. In 1828 the latter was, by act of Congress, made the standard of mass for the Mint of the United States, and although totally unfit for such purpose, it has since remained the standard for coinage purposes.

In 1830 the Secretary of the Treasury was directed to cause a comparison to be made of the standards of weight and measure used at the principal custom houses, as a result of which large discrepancies were disclosed in the weights and measures in use. The Treasury Department being obliged to execute the constitutional provision that all duties, imposts, and excises shall be uniform throughout the United States, adopted the Troughton scale as the standard of length; the avoirdupois pound to be derived from the troy pound of the Mint, as the unit of mass. At the same time the department adopted the wine gallon of 231 cubic in. for liquid measure and the Winchester bushel of 2150·42 cubic in. for dry measure. In 1836 the Secretary of the Treasury was authorized to cause a complete set of all weights and measures adopted as standards by the department for the use of custom houses and for other purposes, to be delivered to the governor of each State in the Union for the use of the States respectively, the object being to encourage uniformity of weights and measures throughout the Union. At this time several States had adopted standards differing from those used in the Treasury Department, but after a time these were rejected, and finally nearly all the States formally adopted by act of legislature the standards which had been put in their hands by the national government. Thus a good degree of uniformity was secured, although Congress had not adopted a standard of mass or of length, other than for coinage purposes as already described.

The next and in many respects the most important legislation upon the subject was the act of July 28, 1866, making the use of the metric system lawful throughout the United States, and defining the weights and measures in common use in terms of the units of this system. This was the first general legislation upon the subject, and the metric system was thus the first, and thus far the only, system made generally legal throughout the country.

In 1875 an International Metric Convention was agreed upon by seventeen governments, including the United States, at which it was undertaken to establish and maintain at common expense a permanent International Bureau of Weights and Measures, the first object of which should be the preparation of a new international standard meter and a new international standard kilogramme, copies of which should be made for distribution among the contributing governments. Since the organization of the bureau, the United States has regularly contributed to its support, and in 1889 the copies of the new international prototypes were ready for distribution. This was effected by lot, and the United States received meters Nos. 21 and 27 and kilogrammes Nos. 4 and 20. The meters and kilogrammes are made from the same material, which is an alloy of platinum with 10 per cent. of iridium.

On January 2, 1890, the seals which had been placed on meter No. 27 and kilogramme No. 20, at the International Bureau of Weights and Measures, near Paris, were broken in the Cabinet room of the Executive Mansion, by the President of the United States, in the presence of the Secretary of State and the Secretary of the Treasury, together with a number of invited guests. They were thus adopted as the national prototype meter and kilogramme.

The Troughton scale, which in the early part of the century had been tentatively adopted as a standard of length, has long been recognized as quite unsuitable for such use, owing to its faulty construction and the inferiority of its graduation. For many years, in standardizing length measures, recourse to copies of the imperial yard of Great Britain had been necessary, and to the copies of the meter of the archives in the Office of Weights and Measures. The standard of mass originally selected was likewise unfit for use for similar reasons, and had been practically ignored.

The recent receipt of the very accurate copies of the international metric standards, which are constructed in accord with the most advanced conceptions of modern metrology, enables comparisons to be made directly with those standards, as the equations of the national prototypes are accurately known. It has seemed, therefore, that greater stability in weights and measures, as well as much higher accuracy in their comparison, can be secured by accepting the international prototypes as the fundamental standards of length and mass. It was doubtless the intention of Congress that this should be done when the international Metric Convention was entered into in 1875; otherwise there would be nothing gained from the annual contributions to its support which the government has contantly made. Such action will also have the great advantage of putting us in direct relation in our weights and measures with all civilized nations, most of which have adopted the metric system for exclusive use. The practical effect upon our customary weights and measures is, of course, nothing. The most careful study of the relation of the yard and the meter has failed thus far to show that the relation as defined by Congress in the act of 1866 is in error. The pound as there defined, in its relation to the kilogramme, differs from the imperial pound of Great Britain by not more than one part in one hundred thousand, an error, if it be so called, which utterly vanishes in comparison with the allowances in all ordinary transactions. Only the most refined scientific research will demand a closer approximation, and in scientific work the kilogramme itself is now universally used, both in this country and in England.*

In view of these facts, and the absence of any material normal standards of customary weights and measures, the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the international prototype meter and kilogramme as fundamental standards, and the customary units, the yard and the pound, will be derived therefrom in accordance with the act of July 28, 1866. Indeed, this course has been practically forced upon this office for several years, but it is considered desirable to make this formal announcement for the information of all interested in the science of metrology or in measurements of precision.

T. C. Mendenhall,
Superintendent of Standard Weights and Measures.

Approved:
J. G. Carlisle, Secretary of the Treasury.
April 5, 1893.

* Bulletin No. 26 U. S. Coast and Geodetic Survey.

* Note.—Reference to the act of 1866 results in the establishment of the following:

Equations.

$$1 \text{ yard} = \frac{3600}{3937} \text{ meter.}$$

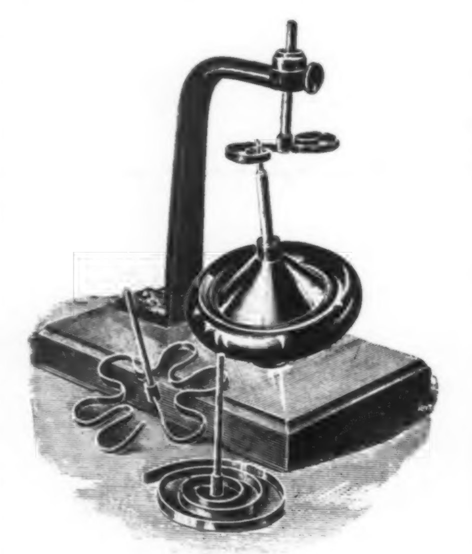
$$1 \text{ pound avoirdupois} = \frac{1}{2\cdot2046} \text{ kilo.}$$

A more precise value of the English pound avoirdupois is $\frac{1}{2\cdot20462}$ kilo., differing from the above by about one part in one hundred thousand, but the equation established by law is sufficiently accurate for all ordinary conversions.

As already stated, in work of high precision the kilogramme is now all but universally used and no conversion is required.

A GEOMETRIC GYROSCOPIC TOP.

The gyroscopic top, of which we publish an engraving from *Engineering*, illustrates in a most interesting



manner some of the most important laws of rotating bodies. The body of the top consists of a shallow bell with a heavy rim The depth of this bell is not, however, sufficient to bring the mass center of the top below its point of support. When placed, therefore, on the agate cup on which it rotates, it falls over, but on giving it a slight spin with the finger and thumb it will remain upright, or in an inclined position, thus illustrating the stability of rotation. The most remarkable property of the top remains, however, to be described. It will be seen that on the base plate, supporting the cup on which the top rotates, there is also screwed a brass standard, which serves as a support for one of the geometric figures, two of which are shown separate below, while a third is in place on the standard. It is while one of these figures is in position the top is given a spin; it rotates in the ordinary way until the upper part of its spindle comes in contact with the geometric figure. When this happens a remarkable phenomenon is observed. The spindle clings to the figure and follows it along one side, round the end of the wire, and back again, keeping on doing this till the speed of rotation falls too low. It is astonishing the way the spindle rounds the sharp corners at the ends of the wire. Quite a considerable pressure is exerted on the wire, which has accordingly to be of comparatively stout section. When spinning freely, the geometric form being removed, the top shows the phenomena of precession and nutation very well.

VENETIAN GLASS.

At the beginning of the thirteenth century the Venetians obtained workmen from Constantinople, and founded workshops that were in full activity till the year 1291, when they were all transferred to the neighboring island of Murano. During the fourteenth century the principal manufacture consisted of beads, imitation jewels, etc., which found a ready market in Asia and Africa. In the fifteenth century a new direction was given to the manufacture, arising from the capture of Constantinople by the Turks and the revival of ancient art in Italy; the former throwing the glass trade almost entirely into the hands of the Venetians, while the latter furnished the artist with fresh and valuable sources of design. It was not, however, until early in the sixteenth century that the very beautiful process was discovered, which at first was religiously kept secret by the manufacturers themselves, and against the divulgence of which the Venetian government passed most stringent orders and threatened the severest penalties. On the other hand, the glassmakers who remained faithful and silent, content with Murano, were made citizens of Venice on that account alone, the highest official positions being open to them. Indeed, such singular honor was paid to them that masters of the art were looked on as little inferior in dignity to the greatest nobles, and peculiar privileges were extended to them. During the whole of the sixteenth and seventeenth centuries Venice was the principal glass manufactory of all Europe, at which every conceivable variety for use and ornament was produced. Early in the eighteenth century the Bohemian manufactures became noted, and the cut glass of that country caught Fashion's ever variable fancy. From that period the art gradually declined at Murano, and the privileges of the glassmakers were annulled. Then came the decay of the republic of Venice, and its destruction by the French at the close of the eighteenth century, since which time, although the manufacture of glass is still carried on at Murano, its glory has quite departed. More even than for the exquisite beauty and delicacy of its contours and proportions, Venetian glass is celebrated for its ornamental patterns in "latticino" or milk-white threadwork enamel, etc. The principal and most characteristic varieties of the manufacture were: 1. Subjects in white or stained glass ornamented with enamel colors and gilding. 2. Glass ornamented with "latticino" or small milk-white threads, which, either milk-white or otherwise colored, are inclosed in the glass; these are spirally twisted into a charming variety of patterns. 3. Pieces in which two sheets of this class are conjoined so as to form a network of "latticino" or other colored threads, between each mesh of which a little air bubble is formed; the extreme delicacy, exactness and minuteness of these pieces have as yet defied all efforts at successful imitation. This kind was known as "Vitro di trina," lace work glass. 4. Mosaic glass, in which slices of colored threads or reeds were placed within two layers of white glass, and fused into masses ready for forming vases, etc. This kind has been very successfully revived in the present century; it was termed "Millefiore" or "Vitro fiorito," flowered glass. 5. Glass in which very small particles of gold are arranged in patterns and fused, or in which metallic filings were dropped in the process of fusion, so as to form patches or blots of gold, etc., termed "Aventurine." 6. Dark mottled glass of many colors fused and blended, which, when held to the light, shows a deep ruby color. To this species the German word "Schmeltze" has been applied. Other varieties are "Schmelz Aventurine," a combination of the last with the gold specks of the Aventurine; frosted or crackle glass and frosted glass with masks, flowers, etc., blown in relief on it from within. Some of the above processes have been imitated in other countries, but Venetian glass far surpasses other varieties in the beauty and novelty of the outlines. The lightness of the material was of so peculiar a nature that it was believed if poison were poured into some of the finest specimens the glass would break to pieces, though Sir Thomas Browne wrote that he did not meet with any specimens of that nature.—*The Architect.*

THE BRAIN AND MEMORY.

What is the brain like, in its capacity of storehouse? and what should we see if we could reduce our stature to infinitesimal proportions and travel along the corridors of the brain? Does it contain galleries of pictures? Is it furnished with sheives and pigeonholes for the classification and care of records and messages? It is impossible to conceive what kind of apparatus or fittings can at once be suitable for storing up pictures and sounds, and all the varieties of impressions received from all the senses. Nor can we discover any curious machinery, even with the microscope, for the structure of the gray matter is so minute as to defy the powers of the lens; and all that we can detect is an agglomeration of minute cells. A calculation has been made regarding the number of these brain cells. It is assumed that every thought or perception is a separate lodger in the mind, requiring an apartment of the brain to itself; and the cells are the apartments. We have to provide accommodation for all the incidents of our everyday life, for all we read in the daily papers, for all that our schoolmasters crammed into us, and all that we have learned since. How is this possible in one small skull? Our conception is assisted by photography, which can print the Lord's Prayer so small that it requires a powerful microscope to read it. Surely then, minute portions of the brain may contain a great deal. The cells vary in size from one three hundredth of an inch in diameter to one three thousandth; and this being known, it is not difficult to estimate the entire number of them in the brain. Dr. Hooke, the mathematician, said 3,155,760,000; but according to Maynert's calculation the number of cerebral cells is only 600,000,000. Seeing that the doctors differ, let us use the slate and pencil ourselves. The thinking power of the brain is believed to reside in the gray matter of the surface. This is a sheet of cellular nerve substance, which is crumpled into con-

volutions through being confined within the narrow limits of the skull. If it were spread out flat, it would be found equal to a layer one inch in thickness and twelve inches long by eleven inches broad—or slightly more—giving a total of 134 cubic inches. If all the cells were one three hundredth of an inch in diameter, there would be room for 27,000,000 of them in one cubic inch, and therefore for 3,618,000,000 in the whole; but since many of the cells are smaller, the total number must be greater. Let us, however, be content with the 3,618,000,000. What is a million? The Bible, Old and New Testaments together, is said to contain about three and a quarter millions of letters; we should therefore have to pile up 1,113 copies of the Scriptures to get a heap containing as many letters as the brain contains cells. As each cell may accommodate one idea or thought, probably even a smaller storehouse would suffice for the wants of the average human creature. On the other hand, when great thinkers require more accommodation, they may perhaps be able to grow more brain cells; and Webster did tell a great American scholar that he had to change the size of his hat every few years.—*Cassell's Family Magazine.*

THE PREVENTION OF TUBERCULOSIS IN ONTARIO.*

By E. HERBERT ADAMS, M.D., Toronto, Physician to St. John's Dispensary, the Nursing-at-Home Mission, the Yorkville Dispensary, etc.

PREVALENCE OF THE DISEASE.

IT is safe to say that no other disease, no form of accident, no civil or other war, has produced so much suffering or caused so many deaths as tuberculosis. During the twenty-five years ending 1886, the average annual total deaths from consumption in England were 50,000. Other tuberculous affections caused 17,700 deaths, making in all a total yearly death rate of 67,700.

In the United States in 1880 the deaths from this disease, estimated from the census returns, were 150,000.

Baer states that the tubercular death rate of the whole world is 15 per cent., and that in prisons it ranges from 40 to 50 per cent. Between the ages of 20 to 40, it is estimated that from one-half to one-third of all deaths are due to tuberculosis.

From the end of 1880 to the end of 1890, there were in Ontario 24,437 deaths from consumption. This does not include deaths from other than the pulmonary form of the disease, and shows that there were as many deaths from consumption alone in Ontario in ten years as from scarlet fever, measles, small-pox, whooping cough, diphtheria, croup and typhoid fever combined. And yet the death rate is not the only point to consider; for the duration of illness, and consequently suffering, is greater in this disease than in most other diseases.

Nor is the disease confined alone to humanity. The cow, and the pig, and other animals are also victims of the scourge.

THE CONTAGIOUS NATURE OF TUBERCULOSIS.

The overwhelming evidences which, during the last decade, have been adduced in favor of the bacillus tuberculosis being the direct exciting cause of tuberculosis have silenced the objections of almost all conscientious scientific doubters.

For sixty-six years, from 1782 to 1848, in Naples, rigorous though somewhat crude laws were enacted for the prevention of consumption on the theory of its contagious nature, and Dr. Lawrence F. Flick, who has carefully studied the condition of Italy before and after the enactment of these laws, states: "It will not be overstepping the mark to place the mortality rate from tuberculosis for the kingdom of Naples and Italy for 1782 at 10 per 1,000 living. In 1887 the mortality rate from all tubercular affections for all Italy was 1·29 per living 1,000. Expressed in figures, the reduction in mortality from tuberculosis in Italy since 1782 ranges from 60 to 90 per cent.

Villemin, in 1865, was about the first to produce tuberculosis in rabbits by inoculating them with tuberculous material; but it remained for Robert Koch, in 1882, to demonstrate that the true cause of tuberculosis of all kinds was the tubercle bacillus ("Die Ætiologie der Tuberculose," *Berlin Klin. Wochenschrift*, 1882, No. 15). He showed the bacillus to be present in all forms of tuberculosis, and, obtaining pure cultures of the bacillus, proved that artificial tuberculosis could be produced in animals by inoculation.

His observations have since been abundantly verified by numerous other observers, and at the present time all reputable medical colleges teach their students how to stain, mount and examine under the microscope sputa or diseased tissues suspected of containing the bacillus tuberculosis. And there is no hesitation on my part in saying that the medical student who is not able to make such examinations successfully should not be allowed to graduate from any Canadian medical college; and also that the general practitioner who does not use this means of diagnosis in consumption is omitting one of the most important elements for the correct and early diagnosis of the disease, and without which he cannot do full justice to his patient.

We know, then, that this peculiar bacillus, which is definite in form and in its susceptibility to certain staining materials, is present in every form of tuberculosis, no matter what organ of the body is affected, and there are few tissues of the body but have been implicated in this disease. We know that this disease is identical in man, the monkey, the cow, the horse, the pig, the rabbit, etc., and that without the presence of this bacillus there is no true tuberculosis. We know also that, by inhalation and inoculation of pure cultures of these germs, the same disease can be produced in animals.

Abundant clinical evidence shows that where these germs most abound there other cases of tuberculosis, both of man and animals, most frequently occur. Many instances are recorded in medical literature of several or all the members of a previously healthy family being carried off with the disease after moving into a house formerly occupied by a victim of tuberculosis. You have all doubtless come across many such cases in your practice; though, on account of the slow and insidious course of the disease and the varying length of time it may take to manifest itself, it is very difficult usually to ascribe the exact source of the contagion.

A case is recorded in Paris where, in the course of eleven years, fifteen out of twenty-three clerks employed in an office died of tuberculosis. Cornet showed that 62·8 per cent. of the deaths among the religious orders for the care of the sick in Germany were due to tuberculosis. Flick's study of the death rate for twenty-five years from tuberculosis in the fifth ward of Philadelphia showed that many of the houses had six to eight deaths, and that over 33 per cent. of the houses where deaths occurred from consumption had more than one case. Cornet has published some statistics on the mortality from phthisis in Prussian prisons. During fifteen years the mortality among males was 45·82 per cent. of all deaths. Confinement, bad ventilation and lighting, together with the presence of the bacillus tuberculosis in the cells, due to improper cleansing of the compartments after the removal of former consumptive occupants, were the probable causes of the great mortality from consumption.

I have stated that the bacillus tuberculosis is the exciting cause of the disease, but there are certain other contributory and predisposing conditions which are also necessary before these germs can manifest their pathological effects. Among these are hereditary and acquired predisposition, bad drainage, bad ventilation and heating, bad sanitation of all kinds, overwork and any debilitating influence whatsoever, and I do not wish to belittle in the slightest manner the great influence such conditions have in the production of the tuberculosis, but merely to emphasize the fact that *without the presence of the bacillus tuberculosis these debilitating influences will not produce consumption or any other form of tuberculosis.*

Heredity has hitherto been considered the chief of these predisposing causes, and we cannot deny that it has considerable influence in the production of the disease, though, undoubtedly, cases ascribed to heredity are due to direct personal contagion, and the infection of previously healthy members of the family long after birth, and not due to any hereditary influence whatsoever.

The great source of infection is, then, the inhalation of the dried expectorations of tubercular patients, the ingestion of tuberculous meat and milk from animals affected with the disease, and by the direct inoculation of tuberculous material into the blood through a wounded or abraded surface.

The first is by all means the greater source of danger, as hitherto little has been done toward destroying the bacilli which are so numerous in the expectoration of tubercular patients. The danger of infection, though at present almost universal, is much greater in the localities where the consumptives reside. The bacilli and their spores have considerable tenacity for life in the dried state, and exist for considerable periods of time after expulsion from their former host. Cornet and others have repeatedly shown the presence of these bacilli in the dust taken from the rooms and surroundings of tubercular patients, and by inoculation of animals with cultures taken from such dust have produced tuberculosis in these animals, which resulted in their death.

METHODS OF PREVENTION.

And now we will consider what measures of prevention are necessary and practicable for lessening this great scourge.

In the first place, the reporting of all cases of tuberculosis to the health department should be made compulsory for physicians, householders and employers. By this means the responsibility would be with the health officer to see that proper methods for the isolation and destruction of the sputa were attended to, and that the surroundings of the patient were in a sanitary condition, and the patient not a source of contagion to others. These matters, in the better class of consumptives, are, as a rule, fairly well attended to on the recommendation of the family physician, but among the poorer classes these conditions are often much neglected. Free microscopical examination of the sputa of the supposed phthisical patients should be made by the health department at the request of any physician, as many physicians are unable to make such examinations themselves.

By means of suitable pamphlets, distributed by the health department, the public should be educated to the fact that the expectoration of every patient in the advanced stages of the disease is a source of contagion to others unless such expectoration is destroyed, and that such patients should never expectorate on the floor or in a handkerchief, but always in a sputum cup or some other special receptacle. Other useful hygienic information in reference to the disease should be inculcated in the same manner.

Tubercular mothers and wet nurses should cease to nurse infants, as their milk is a source of contagion.

The public should be secured from danger from tubercular milk or meat by means of a rigid and systematic inspection of cattle, and specially qualified inspectors should be detailed for this work. The notification of the health authorities by owners of infected animals should be made compulsory.

All tuberculous animals should be condemned and killed after having been valued and paid for by the government.

Railroad and street car companies should furnish receptacles for sputa containing water, or a germicide, in their cars and stations.

There should be careful cleansing and disinfection of the floors and walls of rooms after removal, by death or otherwise, of a consumptive patient.

In prisons and asylums, pulmonary tuberculosis in any of the inmates should be recognized as soon as possible by examination upon entering, and at frequent intervals. Such tubercular inmates should be separated from others, and their apartments cleansed and disinfected after their removal. In such cases the use of sputum cups and cuspidors should be enforced, and their employment in outdoor work, as far as possible, should be urged.

The prevention of consumption would be greatly aided by the erection of special hospitals or sanitaria for the consumptive poor. Municipal and government aid should be given to these institutions. For the poor, the ignorant, the careless and the friendless, and for all consumptives in whose homes or boarding houses proper sanitary measures could not be used, such places would be a great boon, not only to themselves, but to others to whom they would otherwise be a constant source of worry as well as of contagion.

My own personal experience as a resident physician in a sanitarium for consumptives justifies me in saying that better results can be obtained there in many cases than elsewhere, and, under proper conditions, the depressing influence of segregation is not to be felt.—*Canadian Practitioner.*

* Read before the Ontario Medical Association.

CHRONIC INTESTINAL CATARRH.

By C. E. KELSEY, M.D., Professor of Diseases of the Rectum at the New York Post-Graduate Medical School and Hospital, etc.

THE case is that of a physician who has been troubled with constipation for a great many years. The constipation has been constantly growing worse, until, finally, the bowels never moved without a laxative of some kind. He has two symptoms of stricture of the rectum, tape-like stools and goat-like stools. His normal weight is 161 pounds, which was reduced to 135 pounds.

He made a diagnosis of the stricture of the rectum, because he could feel a perfectly distinct band in the rectum with his index finger. I put him on the table and passed my index finger up the rectum. I found it a perfectly healthy rectum, with no stricture as the doctor complained of. The bowel was filled with a large, hard fecal mass. I gave him an injection and washed out this mass. I then introduced my long bougie, shaped exactly like Van Buren's urethral sound with a bulbous end, and without the slightest difficulty I passed up the sigmoid flexure for about 14 inches.

Now, this is a perfectly typical case of just one affection, and an affection for the cure of which patients come to my office every month, with the same diagnosis as the doctor had made for his trouble, viz., stricture of the rectum. A movement of the bowels cannot be had without artificial means, and as the case goes on for a year or two, the difficulty of securing a passage goes on increasing, and the argument that comes to the mind is that the stricture is becoming tighter. The fact of the matter is that a person may have these symptoms all his life without having anything in the history upon which to base a diagnosis of stricture. Listen to what I am telling you, because I get more money, more credit and more reputation as a diagnostician in the treatment of this affection than belong to me. I know of no form of stricture of the rectum you are at all likely to meet with that is not a gradual process attended with destruction of the mucous membrane; and destruction of the mucous membrane before the formation of a stricture will manifest itself in ulceration of the rectum. I will relate a case in point which presents some very remarkable features:

A lady, aged 37, came to me with the statement that from the time she was four years old she never had a movement without the aid of medicine. She was passing blood and slime and there was some intestinal obstruction—a large fecal obstruction, with all the symptoms of stricture of the rectum. I examined her and the examination was negative. I could not pass a bougie of any kind. I sent her home and told her to take nothing but milk for the next 48 hours, and come to see me again. She came on the second day, stating that she had had a large stool. Then I was able to pass a large bougie. She has not taken a laxative from that day to this, but simply a milk diet.

The diagnosis of the case of this doctor is one of chronic intestinal catarrh, and if you are going to cure this trouble, you will do it by milk diet. Let the patients take two quarts and a pint a day, and let the bowels absolutely alone, and at the end of two or three days they will have a natural passage without medicine. I have cured dozens of such cases by this simple method. This patient will get well with the milk diet, and after a time he can be put on the use of meat, fresh vegetables, with very little bread.—*International Journal of Surgery.*

DETECTION OF CHOLERA BACILLI.

By R. KOCH.

THIS process, according to the author, if suitably applied, indicates even a single cholera microbe in drinking water and river water. The method requires that, while observing the well known precautions, a little of the suspected water is added to a solution of peptone and allowed to stand at 37°. If there are in the material only very few cholera bacilli capable of development, they increase very remarkably at the above temperature in from six to twelve hours. In consequence of their avidity for oxygen, they collect upon the surface of the liquid, where, under certain circumstances, they form a fine film, distinctly visible. On the microscopic examination of a drop of the liquid from the surface, the characteristic "comma bacilli" are seen in prodigious numbers.

In order to be quite certain in the diagnosis, we take a drop from the surface of the liquid containing the bacilli and make up gelatin—or, preferably, agar—plates according to the old method. If the gelatin plates are allowed to remain at 22° (or the agar plates at 37°), in from ten to fifteen hours the cholera bacilli (if present) will have grown to characteristic colonies, so that in the most difficult case a demonstration can be secured within about from twenty-one to twenty-seven hours.—*Zeit. fur Hygiene* and *Zeit. Anal. Chemie; Chem. News.*

TO CUT SHORT WHOOPING COUGH IN TWENTY-FOUR HOURS.

THE *Illustrated Medical Journal* says that Dr. Moncorro treats pertussis with a 10 per cent. solution of resorcin by applying the solution every two hours to the periglotteal region with a throat brush. The application is made four or five times at each seance. The theory of the treatment is that the disease is due to a micro-organism and affects primarily the larynx. Cultures of the micro-organisms have been destroyed by the smallest amount of resorcin.

LABOR SAVING INVENTIONS IN AGRICULTURE.

For a generation people have bewailed the desertion of the farms and in the abandonment of a few sterile hill tracts in New England have seen proof of the decadence of agriculture and the threatened loss of social and industrial virtues supposed to be inherent only in a yeomanry.

There is no foundation for the belief that those born upon the farm are deserting the vocation of agriculture, except as may be neccessary to secure employment. The fact that the rural population has diminished in some hill districts of very low fertility, and even in some of the more productive States east of the Mississippi, is not proof of that voluntary desertion of the farm in which so many believe.

That vast numbers leave the farms and seek careers in the towns is true, and it may be true that in some cases the impelling motive is the meagerness of the returns from agricultural labor; yet in most cases the cogent reason has been not the greater possibilities of success in the town, but the absolute necessity of thus relieving the threatened congestion of the rural labor market. To certain natures the town always has possessed an irresistible attraction, and always will possess it; but this has little or no relation to past, present, or possible economic conditions. It is rather an exhibition of the gregariousness which is an element of human nature, and forces people to exchange the isolated and, to them, irksome life of the country for that of the town.

Apart from this, the impelling reason for the constant movement from farm to town is to be found in economic conditions surrounding farm life. These have entirely changed during the last fifty years. This change has been of such a character as to force an ever increasing proportion of those born upon the farm into other vocations; not because of an overpowering desire to leave the farm, but for the reason that it no longer affords the required employment. In other words, those leaving the farm have been crowded away from it by the ever-increasing use of improved processes and labor-saving devices. This is evidenced not only by the findings of the census, but by the course of agricultural production.

While the belated census of 1890 does not furnish all the data desired, yet such as are available show the population to have increased by 170 per cent. between 1850 and 1890, as against an increase of some 231 per cent. in the number of farms and 240 per cent. in the acres of improved land included in the farms. It is true that there might have been an increase of the number of improved acres without a proportionate increase in the number of farms, as was the case between 1880 and 1890; but there could be no increase in the number of farms without a like increase in the number of farmers. Since 1850 the increase in the number of farms in the United States has been a third greater than the simultaneous increase in the population. Therefore, the number of farmers, relatively to the whole population, cannot be less now, but really is 35 per cent. greater than it was forty-three years since; and if the ratio is no less, but greater, it follows that there can have been no such desertion of the farms as has been bewailed.

Should it be pretended that this desertion of the farm is a phase of American social and industrial conditions known only since the civil war, it is merely necessary to show that from 1870 to 1880 population increased 30·8 per cent. and the number of farms 51 per cent., as did the improved acres; and that while the population increased 62·2 per cent. during the twenty years ending with the census of 1890, the number of farms increased some 80 per cent. and the cultivated acres more than 108 per cent.

There can be no doubt, then, that the population has increased much more rapidly since 1886 than either the number of farms or the number of cultivated acres; and that this disparity is not due to the voluntary desertion of the farm by the sons of the farmer, but is attributable wholly to the practical exhaustion of the material from which new farms can be made. This is clearly evidenced every time a fraction of an Indian reservation is thrown open to settlement, as is the corollary that farms are no longer available in numbers sufficient to maintain an increase thereof on a parity with the increase of population. These changed conditions account, in the most complete manner, for the present and increasing inflow to the towns of so much of the increase of the rural populations.

Aside from the proof afforded by the relative increase of population, the number of farms and the number of improved acres, as well as the number of acres actually under the plow, we have, if possible, better proof that the desertion, the voluntary desertion, is wholly mythical, in the volume of production of the more important farm staples as related to the whole population. In 1850 the grain grown equaled 37·4 bushels for each unit of the population. In 1860 the unit quota had increased to 39·4 bushels.

Owing to the devastating effects of the civil war, the quantity produced in 1870 equaled but 36 bushels per capita; and this reduction in the per capita yield, slight as it was, resulted in prices that were highly remunerative. By 1890, however, farms had so multiplied, cultivated acres had increased so much out of proportion to the population increase, and the volume of product was so great, that the quantity of grain grown equaled 56 bushels for each individual, or a half greater than the yield in 1850 or in 1870. So great was the added supply that the cultivator's revenue per acre shrank nearly one-half between 1870 and 1893 as measured in gold; or from a remunerative to an unremunerative level.

In view of these facts, and the recent and present condition of the growers of food and fiber, it is pertinent to ask: What would now be the condition of the farmer had not his sons sought employment in the town? Do not current prices, as well as those of recent years, indicate that there have been too many farmers rather than too few?

As the farmer's revenue has been cut in two since 1870, while those of the artisan and laborer have been advanced to a level hitherto unknown, would not the leaving of the farm have resulted beneficially to those who remained if still greater numbers had left it?

The fact that the quantity of staples grown has been in inverse ratio to the relative numbers employed in rural production indicates the course which the increasing numbers upon the farm have been obliged to take in order to secure the needed employment, and it marks out the course they must take in future and shows just why no more of the sons of the farmer have remained upon the homestead or sought new homesteads.

Prior to 1850, practically the entire agricultural development, as well as the production of the great staples, was in regions more or less densely covered with forests; and there the bringing into cultivation of a farm of eighty acres was the arduous work of a long life. On the other hand, just as soon as the prairie regions were reached, the energetic settler could reduce eighty acres to cultivation by as many days' work with a good breaking team; eighty acres the productive power of which averaged a fourth more than that of the eighty covered with stumps, while the labor cost of production was at least a third less than that during the existence of the obstructing stumps, or, say, another generation. Only by the development and cultivation of the prairie areas were the possibilities of improvement in mechanical aids to agriculture made clear; and there these aids have been and still are most in use.

Such aids and the saving of all the immense expenditures of labor formerly devoted to removal from the surface and placing in stone fences the bowlders of seaboard States, and the conversion of the forests into rail fences and cord wood, has liberated a vast amount of muscular force that is now either employed in actual production on the farm or in the town, or in distributing the wares produced.

Forty to fifty years ago it was the work of years to split the rails and to inclose a quarter section of land. Now, however, the same area can be inclosed with wire fence at a cost no greater than twelve months' wages of an ordinary farm laborer, and the galvanized wire being practically indestructible the fence will last half a century if strung upon posts as durable as locust, mulberry, or cedar. The rail fence required almost constant care; it soon decayed and was a never-ending source of annoyance in the harbor furnished for weeds and vermin. But now the labor of inclosing the farm has been reduced at least three-fourths, and the cost of maintenance nearly to nothing.

Prior to 1850, and indeed until 1870 or later, a very great proportion of rural labor was employed in felling forests, converting the timber into rails and cordwood, carting wood to town, removing stones from the surface, in building stone and other fences, and in other work of development, rather than in production. This labor, being no longer required upon the farm, has been forced into the town, and, as right and natural, the son has gone to the town, while the father has remained in possession of the farm which his labor had hewed out of the forest or reclaimed from the prairie.

Another element has served greatly to increase agricultural production without a relative increase in the number of hands employed. Those who have most bewailed the decadence of the agricultural population have sung loudest pæans over the progress of civilization as evinced in the invention and use of labor-saving devices that are said to have banished drudgery from the farm.

Forty years ago the grain was harvested with the grain cradle, as was the hay with a scythe, and it required ten men to cut, rake, bind, and shock ten acres of wheat in a day. In the fifties came the reaper, employing eight men to cut, bind, and shock the ten acres. This advance toward a higher civilization threw two men out of employment in the harvest season and forced them to that desertion of the farm which the singer of pæans over the reaper has never ceased to bewail.

The earlier form of the reaper was followed in the sixties by the self-raking one, which, depositing the grain in gavels, reduced the number required to harvest ten acres in a day from eight to six, and sent another brace of sons of the farm to seek fame and fortune elsewhere. In the earlier part of the eighties came the table reaper, upon which rode two men who were able to bind the ten acres as the machine traveled, and still further reduced the force by two, who must either sit upon the fence and watch those so fortunate as to retain employment, or go to town for the work no longer obtainable on the farm.

Two or three years later came the wire self-binder, which circled the sheaves with a band of steel, dispensing with the two men who bound upon the table reaper, and simplified the matter by sending to the town all but the farm's owner, who operated the machine, and the son or laborer who placed the grain in the shock, and also reduced harvest wages to nearly the ordinary monthly rate. The wire binder was shortly displaced by the twine binder, which has reduced the cost of operation somewhat, but has not materially diminished the amount of labor employed, except as the machines are now made larger, cutting a wider swath.

The result of these successive improvements is that, whereas it required ten men to cut and place in shock ten acres of grain forty years ago, three men now, with the aid of four horses, can place from sixteen to eighteen acres in the shock; and wherever the ordinary harvest time is fairly dry, the "header" enables eight men to cut and place at once in stack thirty acres in a day, the labor saving effected by the header being greater even than that with the self-binder, while the grain is at once secured from the deterioration usually resulting from weathering in the shock. By this progressive advance toward a higher civilization, four men out of the five formerly employed in harvest work have been actually and visibly pushed off the farm and into the ranks of those seeking work in the towns. The work of the farm has deserted the farmer's son; not the son, the work.

Equally destructive of employment on the farm have been the mower, the wheeled hay rake, the hay tedder, the hay loader, the self-feeding steam thrashing machine, the gang plow, the grain drill, the broadcast seeder, the two-horse corn cultivator, the corn lister, and a thousand and one other labor-saving devices; and when to the employment-lessening effect of all these we add the reduction of labor due to cessation of forest clearing, rail and stone fence building, and the conversion of timber into fuel and its carting to town, we can get some idea of that irresistible force which has crowded so many of the sons of the farm off the soil, and which but for the enormous increase of the number of farms up till the middle of the nineties would have crowded still greater numbers into the ranks of those engaged in manufactures and distribution, as it certainly will crowd them in the years to come.—*N. Y. Sun.*

PAPHINIA GRANDIS.

PAPHINIA GRANDIS.

The Paphinias form a pretty genus, of which but few species are at present in cultivation. In P. grandis, the largest and most beautifully colored of the forms of Paphinia cristata (which is also known as Lycaste cristata and Maxillaria cristata), we have a species with large flowers, whose petals and sepals are of a creamy-white color, with intense blackish-purple spots; the column of a pale yellow and spotted with purple;

the lip white and fringed. The plant from which our figure was taken was shown by Messrs. Linden, L'Horticulture Internationale, Parc Leopold, Brussels, at the meeting of the Royal Horticultural Society on the 24th of October. Paphinias do best in the East India house, in pans or baskets filled with sphagnum moss, peat and charcoal.—*The Gardeners' Chronicle.*

ANTHURIUM WAMBECKIANUM.

ON October 10 last Messrs. Linden, L'Horticulture Internationale, Brussels, showed at the meeting of the Royal Horticultural Society, among several other novelties and varieties, a plant under the above name, which possessed a spathe of dead white, not varnished, a spadix of pinkish-white and leaves of the usual simple character. As a distinct-looking variety of robust growth, it is worthy of cultivation for the contrast it affords to the varieties of Anthurium which have bright colored spathes. A first-class certificate was granted to it by the Royal Horticultural Society. —*The Gardeners' Chronicle.*

THE BEAUTIFUL COLORS OF AUTUMN.

IN regard to the vivid coloring of our autumn trees and shrubs, there is a diversity of opinion as to whether the coloring is better in dry seasons than in wet ones. Some contend that as coloring is better in a starved out tree than in a well fed one, it should be better in dry seasons, when there is difficulty in finding enough moisture properly to sustain the foliage. In my own experience I have never seen evidence to convince me on either side. I have seen dry falls when the foliage would appear to fade and drop with but little or no color. This fall was very dry in the early part of it, but there have been many rains later. The foliage of such kinds as usually color was never more brilliant.

In the early part of the season the sumachs made a great display. *Typhina* and *glabra* changed to a rosy red color, and the Western one. *Rhus aromatica*, was also pretty. All three of these form thickets in time if undisturbed, and when in masses the scene is a pretty one. The sour gum, *Nyssa multiflora*, is a blaze of red as seen in some pastures of New Jersey, but with us it is not so pretty, and it drops its foliage early. On the other hand, the sweet gum, *Liquidambar styraciflua*, is a tree of magnificent appearance. There are green, yellow, bronze and red colors to be seen at one time, as the different leaves change, and it holds its foliage late.

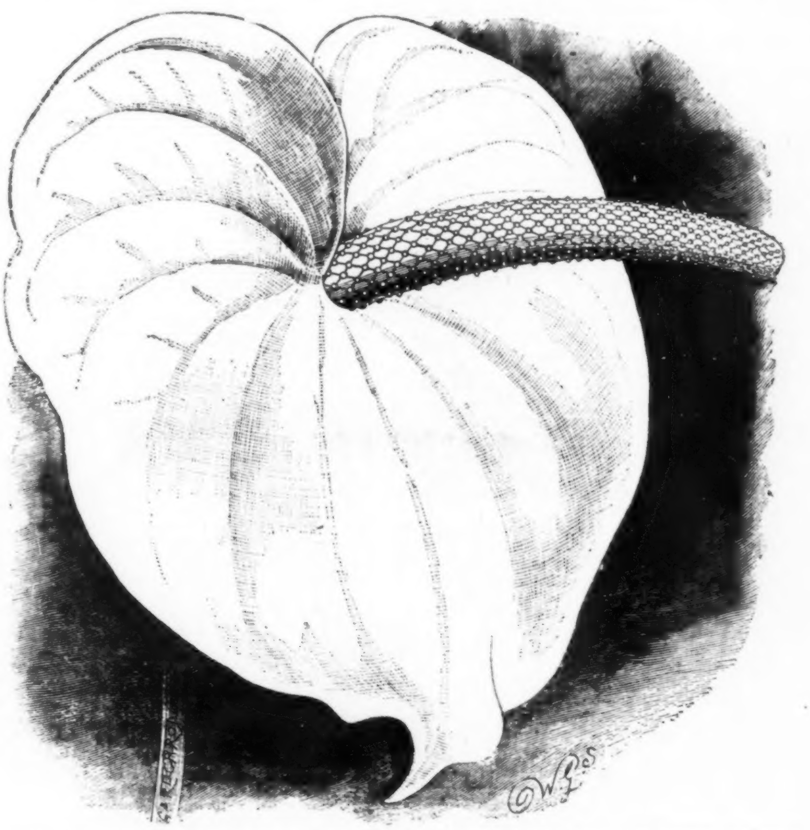
It is no wonder the dogwood is so esteemed by landscape gardeners. The lovely large white flowers in spring, the red berries of autumn, and its red leaves, make more points in its favor than most trees can command. It is now the 8th of November as I write, and the foliage of this tree is still in full display of yellowish-red color. The new red flowered one is distinguished now by its much darker, almost black leaves. There is a shrub like dogwood, the *Cornus alba*, the foliage of which changes to a dark red now, as also do its branches. Strangely enough, when spring comes, these same branches lose their red color and become almost green for the summer.

Acer rubrum, the scarlet maple, has two claims to the name. In the earliest days of spring the red flowers appear, sometimes in great abundance. The seeds immediately follow and in a week or two have taken on an intense scarlet color. Many beholders mistake this display as being made by flowers. When it comes to the autumn, however, it is not every red maple tree that makes a display. There are some old trees here that never change to a pretty color, and others that always do, and the same may be noted among younger trees. Whether these trees would behave differently if they were in different situations is the question. Or is the coloring inborn in some and not in others?

Although the list of oaks is a large one, there are but few that make much autumn display. The scarlet (*Quercus coccinea*) is the best of all. As with the red maple, there are some—whether from situation or not, I cannot say—which are always handsomer than others. I know of trees now that have every leaf of a dark blood-red. When, as in the case of this one, the coloring is perfect, it is the most striking of all autumn trees. And it is, besides, one of the last of all trees to lose its leaves for the season. The red oak comes next in value, and where no scarlet one is near it for comparison, it sometimes passes for the latter kind, so nicely does it color. Sometimes the pin oak will take on a good deal of color, and then, with its pretty foliage and drooping branches, it is a much admired tree.

The sorrel tree, *Oxydendron arboreum*, is one of the brightest colored of all trees, being of an intense scarlet. It is seen in collections mostly as a shrub; nevertheless, in Virginia and North Carolina it makes a large tree in the mountains. It is a beautiful shrub or tree at all times. The rare Franklin tree, *Gordonia altamaha*, besides that its large, camellia-like flowers are produced from August until frost, is scarcely behind the best of trees in the pretty bronze-red color of its leaves now.

Among more shrub-like things, there are a number of very pretty ones. The snowy mespilus, *Amelanchier canadensis*, the *Pyrus arbutifolia*, and the rare *Fothergilla alnifolia* are famed for their pretty leaves, and among andromedas there are the *mariana* and *recurva*, both decidedly pretty. The purple plum has purple leaves all the season through, and maintains them of the same hue until hard freezings come. No other blood-leaved plant does this.



ANTHURIUM WAMBECKIANUM—SPATHE WHITE; SPADIX PINKISH-WHITE.

The bilberry, *Vaccinium corymbosum*, surpasses all other shrubs in the brilliant foliage it now displays.

Among foreign shrubs, the blood-leaved Japan maple is now of a golden-yellow color, and the Japan ivy, *Ampelopsis veitchii*, is a blaze of bronze and crimson.

Germantown, Pa. JOSEPH MEEHAN.

In reference to the varying coloring in the same species, spoken of by Mr. Meehan, we may note that in a small group of Japanese maples in Washington Park, Albany, this fall, one was of a vivid crimson, while its neighbor only slightly changed color, and to a greenish-yellow hue. The foliage of the latter tree remained on long after the former was bare. The *Ampelopsis veitchii* varies greatly on different house walls. One will be a fine crimson, another bronze, another greenish-red. Varying soil and situation seem to have much to do with the coloring, at least of vines. EDS.—*Country Gentleman.*

ANOMALIES IN TROPICAL CANE GROWTH.

By THOS. MANN CAGE.

THE tropical cane springs either from the eye of the mother cane planted or from the stubble or ratoon—that portion of the cane under ground from which the stalk has been severed. The eye or embryo cane is made up of a number of minutely folded leaves, the outer pair having a silicated coating to protect the delicate inner germ. When the germ has elongated in the soil to the length of an inch there are about seven well developed leaves, with at least one eye at the base of the outer one which would produce a cane under favorable conditions even at that early stage of growth. The rapid or tardy germination or growth of the cane planted, or the ratoon, depends on the amount of heat and moisture, and also the texture and manurial richness of the soil.

The amount of earth covering is also a prime factor, for where it is in excess with plant or ratoon the feeble heat of early spring cannot penetrate to any considerable depth, and in consequence the eyes remain dormant, whereas with a light covering of compressed earth they would earlier receive that amount which would be requisite for generation and leaf development.

The ideal surroundings for the canes to make rapid development and early growth in the spring are a fertile, friable, somewhat light covering of earth, with that on each side in close proximity in like condition, where the drainage is such that an excess of moisture cannot remain about the base of the young plants. In other words, as soon as the time for freezing temperatures has passed the earth should be removed from the canes, that there will be but a light covering (except during periods of drought), with well pulverized earth banked to the sides of what composes a somewhat flat ridge to insure the rapid flow of the spring rains from the fields.

To persistently aim at the ideal in agriculture (when correct in principle) is to enhance the supremacy of mind over matter, and thereby augment the production of soils by more enlightened field manipulations. The more the agriculture of the cane is studied the stronger becomes the conviction that, particularly here in Louisiana, where the growing season is limited as compared to many other tropical cane countries, too much care cannot be bestowed on the young canes in the early stage of growth. The more thorough the drainage and tillage and the intelligent application of the requisite plant food, the better will be the tonnage yield and sucrose per ton—in a measure regardless of meteorological influences.

The results of observations made in the same field on October 15 may throw some light on the subject, and to some extent corroborate the correctness of the above premises.

It may be expedient to state that where the canes were examined the field has a depth of about ten acres from the ridge of the bayou bank, with a fall such that the drainage of the land at the lower extremity is very defective. The soil varies from sandy to what is erroneously styled terre grasse (loam), as after a few years of cultivation it becomes a tenacious bluish-black clay. The sandy soil has been under cultivation for fifty years, and the lower land ten at most. The ratoons examined in the different portions of the field had sprouted about the same time in the spring, each having thirty-five leaves. The first, grown on the sandy soil, cut eighty-four inches for the mill, the second, on the mixed soil, cut fifty-one inches, and the third, on the stiff clay, only twenty-one inches.

The first sixteen joints of the first cane measured 41 inches in length from where the lower leaf sprang, the second 21 inches, and the third only 7 inches. There were in each portion of the field canes with from twenty-eight to thirty leaves, going to demonstrate that they came up later, which is proved by the fact that in another part of the field, where some canes were planted about March 1, there were five or six more leaves; these were found where the canes were planted on April 1. The canes developed about five leaves per month, regardless of length of joints, the quality of soil cultivation or drainage. Where the latter was good, the soil fertile and the cultivation ample, the growth was excellent, notwithstanding the fact that for seven weeks after the middle of June the canes were virtually without rain.

The average length of the first sixteen joints of the first cane was 2·56 inches, of the second 1·31 inches, and of the third 0·43 inch. The marked characteristics of those joints had been formed prior to June 15, going to demonstrate that under average after-conditions the possible tonnage yield per acre is most notedly influenced in the early stages of growth of the canes. Roughly estimating with an average stand, etc., the elongation of each three inches over the fields gives an additional ton of cane per acre, and we would have had 13·66 tons from the first canes, 7 tons from the second, and 2·33 tons from the third canes had they matured at that stage of growth.

The tonnage (when cut) per acre from each piece was about twenty-eight for the first, seventeen for the second and seven for the third. From the above one is led to the conviction that the possibilities of a heavy tonnage yield per acre are to a great extent decided at a much earlier date than is generally supposed in this country, where the period of growth is limited. With very favorable conditions of rainfall, fertility, etc., much of the loss sustained at an early period may be regained by a growth of about an inch a day during summer; but climatic conditions are too variable to take such chances when possibly avoidable.

The land on which the smaller tonnage was grown is probably richer (according to chemical analysis) than that where the largest yield was had; but the physical condition was such, owing to defective drainage, etc., that the roof growth was meager, and consequently the stalk elongation was seriously retarded, and tons of cane per acre were lost early in the year, which could not proportionately be made up later on, as the rains, etc., favorable to the one proved of equal benefit to the other. The crop well planted is the crop half made, and its judicious nursing in the early stages of its growth will do more to insure large yields than the later after-cultivation.

To the practical eye, the appearance of the fields about the first of July is a good indication of the possibilities of the canes, with favorable weather during summer. To stimulate early root and leaf development would appear to be the means by which large tonnage yields can be reasonably assured, and that can be accomplished by an adequate supply of soluble available plant food in the soil and thorough tillage to counteract the effects of climatic extremes.—*La. Planter.*

RUINS IN MASHONALAND.

SEVERAL letters received by Mr. Theodore Bent from Mr. Robert M. W. Swan, who is exploring the country between the Limpopo River and Matabeleland, have been made public. In these letters Mr. Swan announces the discovery of several fresh ruins similar to the famous remains explored by Mr. Theodore Bent at Zimbabwe, which were described in the *Journal* for July 29 last. From the general appearance and the

method of construction of the newly found ruins, and more particularly from their orientation, Mr. Swan has no doubt that they were built by the same race as the Zimbabwe Temple, and are of Semitic origin. The tract of country in which the new finds are situated is of so poor a character and so destitute of even mineral wealth that it is now uninhabited. It is, therefore, a matter of difficulty to explain what attracted the builders of these structures in the district. From various indications, however, Mr. Swan concludes that these people came for gems and precious stones. In support of this theory Mr. Swan refers to the beautiful pebbles which abound in the vicinity. Besides temples, the hills are crowned with the remains of several forts, which would seem to indicate that the Phenicians or other explorers conducted their work under much the same difficulties with regard to the native inhabitants as confront European settlers and prospectors at the present time. Some most interesting results were given by a small tumulus which was excavated by Mr. Swan at the great ruin near Sewaloli, the tumulus consisting of wood, ashes, stones, soil, a considerable quantity of bones, and much pottery. The latter included several little sun images of terra cotta and many fragments of vessels. The position of the heap, which was situated exactly on a prolongation of the main axis of the adjacent temple, suggested the idea that it was a point at which the dead were cremated.

SPONTANEOUS COMBUSTION.*

When an inflammable substance ignites or becomes incandescent without the application of fire or other apparent cause, it has been customary to speak of it as spontaneous combustion, a term which I think I shall be able to show you presently does not correctly express the actions which lead to this apparently mysterious result.

Early in the eighteenth century a woman was found burnt to death under circumstances which gave no clew as to the cause of the accident, and in order to satisfactorily explain her death, the theory of spontaneous combustion was devised by the experts of the day, and was generally accepted at a time when little or nothing was known of what takes place during the process which we know as combustion; but as the years rolled on, men's views upon this important subject became wider and more exact, until, in the latter part of the last century, the great French philosopher, Lavoisier, partly by his own experiments and partly by the teachings of the work done by others, gave us a true knowledge of combustion and the changes which take place when a body is burnt; while the commencement of this century marked still further the advance of our knowledge in this direction, and also as to the conditions necessary for continuing the combustion or burning of any inflammable substance.

We now know that from the nature of combustion it is impossible for the human body to undergo spontaneous ignition or combustion in the way in which the novelists and scientific experts of the last century believed possible, but there are few among us who have not heard of, and even come across, cases in which large masses of coal, small quantities of oily rags or waste, and hayricks which have been made from grass stacked before it was thoroughly dried, have ignited without any apparent cause, and have kept alive in our minds and on our tongues the term "spontaneous combustion;" and you must pardon me if I commence my lecture this evening by reviewing the teachings of Lavoisier's classical work, and then apply the conclusions we arrive at to those cases of spontaneous combustion which we meet with in our daily work.

The theory of combustion which was generally accepted during the last century was that every combustible body contained within itself the products of combustion combined with a "something" called phlogiston, and when the substance was burnt, this phlogiston escaped, giving the flame or incandescence of combustion, while the products were set free. This theory could not, however, for long stand the test of exact experiment, and as soon as Black introduced the balance into scientific research, it was found that when any substance underwent combustion, the products weighed more than the body before it had been burnt, the reverse of what one would have expected had the phlogistic theory been correct.

During the last century lived Joseph Priestley, one of the most remarkable men this country has ever claimed as her own—a man so varied in his attainments, and so energetic in his life and labor, that he published over one hundred different works dealing with every conceivable subject, from theology to science; but it was in the latter field that he especially shone, and the greatest achievement of his life was the discovery of the gas which we now call oxygen, a discovery which he communicated to his friend Lavoisier.

Lavoisier at once saw the importance of the discovery which Priestley had made, and then conceived and carried out an experiment which has become historical as proving for the first time beyond doubt the fact that the air was not a simple elementary substance, but contained two perfectly distinct gases—oxygen and nitrogen.

Lavoisier placed in a long necked retort about four ounces of mercury, and so arranged the apparatus that the air above the mercury in the retort should freely communicate with the air in a measured receiver, all contact with the outer air being prevented by standing the receiver in a vessel of mercury. He now heated the four ounces of mercury in the retort nearly to its boiling point, and kept it at this temperature for twelve days and twelve nights. At first no change took place, some of the mercury merely distilling into the upper part of the apparatus and falling back again; but presently some little red specks began to appear on the surface of the metal, and increased in amount for several days, but at length ceased to form; and after continuing the heating for a day or two longer, in order to make sure that the action was completed, he allowed the whole apparatus to gradually cool down again to its original temperature.

Before starting the experiment he had carefully measured the air in the apparatus, which amounted to fifty cubic inches, and the first thing which he now noticed was that of this forty-two cubic inches only remained, and that this residual gas had lost all the most characteristic properties of air; a taper plunged into it was at once extinguished, a mouse placed in it died after a few moments; it would, in fact, neither support life nor combustion, and he recognized it as a gas discovered some three years before by Rutherford, and now called nitrogen.

He then collected the red film formed on the surface of the mercury, which weighed forty-five grains, and heated the powder in a hard glass tube to a higher temperature than that at which it had been formed, when it again broke up, leaving behind metallic mercury, and yielding eight cubic inches of a gas which had to an exaggerated extent all the properties which the air had lost—a gas which he at once recognized as being the oxygen or "vital" air which Priestley had discovered in 1774.

It was in this way that the air was shown to consist of the two gases, oxygen and nitrogen, and we know from experience that air is necessary for carrying on those cases of combustion which we ordinarily meet with, and the quickest way to extinguish a fire is to cut off the supply of air from it.

Having reached this point, the next question which suggests itself is, Which of the constituents of the atmosphere is it which supports and carries on combustion, and how does it act in doing so? And the answer to these points can most readily be given in nature's own words, by carefully translating the result of a few simple experiments.

Here are two gas jars, the one containing oxygen, the other nitrogen, and, taking a small ball of tow soaked with turpentine which is burning vigorously, I plunge it into the atmosphere of nitrogen, when it is at once extinguished; but on now relighting it, and plunging it into the oxygen, it burns far more fiercely than before, and emits a most brilliant light. If we continued experimenting in this way, we should find that everything tends to confirm the impression gained from our first experiment, and we soon learn, as Lavoisier did, that anything which will burn in air will burn with still greater vigor in oxygen, while nitrogen alone instantly stops the combustion of those bodies which require air to enable them to burn; indeed, we might go a step beyond Lavoisier's experiments, and find that many bodies not looked upon as combustibles, such as iron and zinc, burn with considerable brilliancy in pure oxygen; and it is from these facts that we came to look upon oxygen as our great supporter of combustion.

The enunciation of these truths by the great French philosopher was one of the most important steps in the history of science, but with increase of knowledge we find that we must still further widen our views with regard to combustion, and must take care not to fall into the error of looking upon those substances which will burn in air or oxygen as the only combustibles, and oxygen as the only supporter of combustion; we find, indeed, that these terms are purely relative, and a substance which we look upon as a combustible may, under altered conditions, become a supporter of combustion. Indeed, a body like coal gas, which burns in air or oxygen, will support in turn the combustion of air, and we can experimentally show that it is just as easy to have a flame of air burning in coal gas, as, under ordinary conditions, to have a flame of coal gas burning in air.

Again, we find that many cases of combustion will take place without the presence of oxygen or those substances generally looked upon as combustibles, and we can take a metal like antimony, and cause it to undergo brilliant combustion by throwing it in a powdered condition into an atmosphere of a gas called chlorine, although neither the metal nor the gas answer to our general ideas as to combustible or supporter of combustion.

If we examine carefully all cases of combustion, we find that in them we have a body with certain definite properties of its own, uniting itself with something else to form what we call the products of combustion, which are equal in weight to the sum of the weights of the two bodies uniting, and which have characteristic properties differing from those of the original substances, an action which we term one of chemical combination; and extended experiments show us that in order to obtain a true conception of combustion, we must look upon it as "the evolution of heat during chemical combination."

The rapidity with which chemical combination takes place varies to a very great extent with surrounding circumstances, and inasmuch as heat is very rapidly dissipated it often happens that where a chemical combination is slow, the heat produced by it is given off as rapidly as it is generated, so that the temperature of the mass becomes but little raised, and escapes detection by our senses. For instance, if I take a steel watch spring, and having ignited a small piece of German tinder attached to the end of it, plunge it into a vessel of oxygen gas, the combustion of the tinder ignites the watch spring, which burns away in the gas with the greatest brilliancy, and the evolution of heat is sufficient to fuse some of the metal, the result being that the watch spring is converted into a chemical compound of iron and oxygen. If, instead of bringing about the combination of the iron and oxygen as we have done in a few seconds, we allowed it to remain in moist air for two or three months, combination with the oxygen of the air would result, and the metal would rust away, and if the weight of metal had been the same in each case, and the same weight of oxygen had been combined with, exactly the same amount of heat would have been generated in each case; but in the rapid combustion of the metal, this heat, being all generated in a few seconds of time, would have made its presence perfectly manifest; while when the same action is spread over a long period, as in the rusting of the metal, the heat being dissipated as it is generated escapes our notice; and there are many among us who would smile at the idea that the rusting of their garden railings was giving rise to any increase of temperature.

In this case the heat generated by the combination of the iron with oxygen was made manifest by raising the burning metal to a high temperature in the presence of oxygen free from the diluting action of the inert nitrogen which is mixed with it in the air; but we can do the same thing by taking the iron in a very finely powdered condition, so that a very large surface shall be exposed to the action of the oxygen of the air. I have here iron in this condition, sealed up in a glass tube, and on opening and shaking out the finely divided metal into the air, it at once enters into combination with oxygen, and the heat generated is sufficient to make it red hot. If, however, the same weight of iron in a compact form, such as wire, be taken, a long period of time, extending perhaps over years, would be required for its conversion into oxide by air and moisture, and the heat generated would be spread over such a duration of time that it would be inappreciable unless the conditions were such that the heat was unable to escape or the surface of metal exposed very large. A case of this kind occurred during the manufacture of the Mediterranean telegraph cable, which was inclosed in a strong casing of iron wire, and tightly coiled in water tanks, one hundred and sixty three miles of cable being wound in a coil thirty feet in diameter. Owing to a leak in the tank which contained the cable the water ran off, leaving the wire casing exposed to air, and the moist metal oxidized so rapidly that sufficient heat was generated to form considerable quantities of vapor, and to give rise to serious fears as to the softening of the insulating material of the core.

Many cases of chemical combination with the oxygen of the air take place in nature which are so slow that the heat evolved during the action escapes our senses, and indeed all cases of decay are processes of this kind, and the action is termed one of "slow combustion."

A tree left to rot upon the ground gradually disappears in the course of years, being mainly oxidized into gaseous products, such as carbon dioxide and water vapor, and yet scarcely any evolution of heat is observed, although the same amount of heat is generated as if the tree had been cut into logs and burnt.

In all cases slow combustion is accelerated by increase of temperature, and the higher the temperature the more rapid becomes the chemical action, and all combustible bodies, at a certain temperature, undergo what is termed "ignition," that is to say, a temperature is reached at which slow combustion passes into ordinary combustion with manifestation of flame or incandescence, the chemical combination being then so rapid that the heat evolved is manifest to our eyesight, while a still greater increase in the rapidity of combustion will in some cases bring about the most rapid form of combustion, which we term "explosion."

Many substances are capable of undergoing all three rates of combustion. For instance, it can readily be proved that when organic substances containing hydrogen undergo decay, some of the hydrogen present unites with the oxygen of the air to form water, and the heat generated by the combination is spread over so long a period that at no one moment of time is it perceptible to the sense. If, however, hydrogen gas be confined under pressure in a gas holder, and allowed to escape through a jet into the air, on being ignited it burns with an intensely hot flame, the heat energy of which can be converted, by suitable contrivances, into other forms of energy, such as mechanical force. In this case as much hydrogen is converted into water in the course of a minute as would have been formed in some years by the process of slow combustion, and the increase in calorific intensity obtained is solely due to the increased rate of combustion, the total thermal value of the hydrogen being the same, whether it is burned by a slow process taking years or a rapid one in a minute. If now the same volume of hydrogen be mixed with sufficient air to supply it with the oxygen required to convert it into water, and if a light be applied to the mixture, the hydrogen being side by side with the oxygen necessary for its conversion into water, combustion takes place with enormous rapidity, and the intense heat generated expands the vapor formed to such an extent that an explosion results.

We have now seen that during the decay or slow oxidation of combustible bodies heat is generated, and that it is only necessary for this heat to reach a certain point, *i. e.*, the point of ignition, for the little noticeable slow combustion to become ordinary combustion with its manifestation of flame and incandescence, and it is this action to which the term spontaneous combustion has been given.

When the combustible substance has a great affinity for oxygen and at the same time a low point of ignition, spontaneous combustion will take place with great ease. Indeed, in some cases, such as that of phosphorus, we are obliged to prevent the access of air to the body if we wish to prevent ignition taking place, and we also find that the finer the state of division of the substance, the more readily will its spontaneous ignition take place, not because dividing the body up in any way lowers the point of ignition, but because the increase in the size of the surface exposed to the oxidizing action of the air is so much increased that the heat is generated with greater rapidity than it can be dissipated. If we take a piece of phosphorus, and expose it to the action of the air, it almost directly commences to give off white fumes, and if the weather is warm, it will in the course of a short space of time even ignite; in cold weather, however, it may be left until it has nearly all undergone slow oxidation without ignition. If, however, we dissolve it in the liquid called bisulphide of carbon, and pour some of this solution upon a piece of blotting paper or linen, the carbon bisulphide, being highly volatile, will all evaporate, and leave the phosphorus in such a fine state of division that it will at once spontaneously ignite.

In practically all of the cases of spontaneous ignition which come under our notice, we have the heat evolved during the slow combustion kept in by the presence of a mass of non-conducting material, and this heat being unable to escape gradually grows higher and higher, the chemical combination becoming more and more rapid as the temperature increases, until we reach the point at which ignition of the mass takes place.

Sometimes, also, the increase in temperature necessary to bring about spontaneous ignition is partly due to physical actions. If a gas be suddenly compressed heat is always evolved, a fact prettily shown by the so-called fire syringe, in which the heat evolved by the compression of air is sufficient to ignite a piece of German tinder.

Certain bodies have the power of absorbing many times their own volume of gases, and in doing this they not only give rise to a certain increase in temperature, due to the compression of the absorbed gas

* A lecture to workingmen, delivered by Prof. Vivian B. Lewes, at Nottingham, in connection with the British Association.

upon their surfaces or in their pores, but they also increase the chemical activity of the gas so compressed.

Carbon is one of those substances which possess to an extraordinary degree the power of attracting and condensing gases upon their surface, this power varying with the state of division of the particular form of carbon used. The charcoal obtained from dense forms of wood, such as box, exhibits this property to a high degree, one cubic inch of such charcoal absorbing—according to Saussure—

Ammonia gas	90 cubic inches
Sulphureted hydrogen	55 " "
Carbon monoxide	35 " "
Ethylene—oleflant gas	35 " "
Oxygen	9·25 " "
Nitrogen	6·5 " "

This absorption is very rapid at first, but gradually decreases, and is, moreover, influenced very much by temperature. It is at first purely mechanical, and itself causes a rise of temperature, which in the case of charcoal formed in closed retorts, as in preparing alder, willow and dogwood charcoal for powder making, would produce spontaneous ignition if it were not placed in sealed cooling vessels for some days before exposure to air. The rate of absorption varies with the amount of surface exposed, and is, therefore, able to take part in this condensing action, so that when charcoal is finely powdered, the exposed surface being much greater, absorption becomes more rapid, and rise of temperature at once takes place. If, after it has been made charcoal, it is kept for a day out of contact with air, and is then ground down into a powder, it will frequently fire after exposure to the air for thirty-six hours, while a heap of charcoal powder of one hundred bushels or more will always ignite. It is for this reason that in making the charcoal for powder it is always kept, after burning, for three or four days in air-tight cylinders before picking over, and ten days to a fortnight before it is ground.

There are several very interesting points with regard to the spontaneous combustion of charcoal, which call for more attention than has yet been devoted to it. It is self-evident that the more porous a body is, the greater amount of exposed surface will be available for the condensation of gases, and the great power that charcoal has of absorption is undoubtedly due to its great porosity. Now the temperature at which wood can be carbonized varies very considerably, and wood will begin to char, that is to say, will begin to be converted into charcoal, at temperatures very little above that of boiling water, and in the manufacture of some of the newer kinds of gunpowder the charcoal is formed by heating with superheated steam.

Charcoal formed at this low temperature, however, still contains large quantities of hydrogen and hydrocarbons, and is not nearly so porous as charcoal made at a high temperature; and although the diminution in porosity reduces the quantity of oxygen absorbed, yet another cause which tends still more to dangerous rise of temperature comes into play.

When a substance condenses oxygen upon its surface from the atmosphere, the gas is in a very chemically active condition, and will bring about chemical combination with considerable rapidity. For instance, if a piece of platinum foil be heated to redness, so as to drive off all gases from its surface, and be then allowed to cool until it ceases to be visibly red, and is held in a stream of mixed air and coal gas, or air and hydrogen, it again becomes red hot, owing to the chemical combination of these substances upon its surface; that is to say, it has been able to condense these gases together and set up combustion.

If now charcoal be burnt at a high temperature, the carbon is in a dense condition, and resists to a considerable extent the setting up of chemical action by the oxygen condensed and absorbed in its pores; but if it has been formed at a low temperature, this condensed oxygen will rapidly act upon the hydrocarbons and hydrogen still remaining in the mass, and will raise in this way the temperature to a dangerous point; and it is more than probable that very many unexplained fires have been brought about by beams and woodwork becoming charred in contact with flues and heating pipes.

It has been experimentally determined that when wood has been charred at 500° it will take fire spontaneously when the temperature is raised in the presence of air to 680°, and that when wood has been carbonized at 260° a temperature of 340° only is required for its spontaneous ignition.

If a beam is in contact during the winter months with a heated flue, or even steam pipes, it becomes carbonized upon its surface, and during the summer, when the flue or pipe is probably not at work, it absorbs air and moisture, and during the next winter it again becomes heated and further carbonized, while the moisture and air are driven out, leaving the pores in a condition eminently adapted for the absorption of more air as soon as the temperature is allowed to fall, and in many cases sufficient heat is generated to cause the charred mass to smoulder and, when air is freely admitted to it, to burst into flame.

In the case of charcoal burned at a higher temperature, it may be taken that the cause of heating is to a great extent physical, while in the low-burned charcoal it becomes chemical as well as physical, and it is this chemical action which is the most dangerous, and acts in most cases of spontaneous combustion.

The spontaneous ignition of coal has been the cause of an enormous number of serious accidents, and the earliest theory as to its cause was that it was due to the heat given out during the oxidation of the pyrites or "coal brasses," which are compounds of sulphur and iron, and are present in varying quantities in nearly all coal. This idea has held its ground nearly up to the present time, in spite of the researches of Dr. Richters, who, twenty years ago, showed the explanation was an erroneous one, and even earlier, in 1864, Dr. Percy pointed out that the cause of spontaneous ignition was probably the oxidation of the coal, and that the pyrites had but little to do with it. Pyrites is found in coal in several different forms, sometimes as a dark powder closely resembling coal itself, and in larger quantities in thin golden-looking layers in the cleavage of the coal, while sometimes again it is found in masses and veins of considerable size. These masses, however, are very heavy, and are carefully picked out from the coal, and utilized in various manufactures. The yellow pyrites, and even the dark varieties, when in the crystalline form, remain practically unaltered, even after long exposure to moist air, but the amorphous and finely divided portions will oxidize and effloresce with great rapidity, and it is during this oxidation that the heat is supposed to be generated.

Some coals that are very liable to spontaneous ignition only contain $0·8$ per cent. of pyrites, and if we imagine this to be concentrated in one spot instead of being spread over the whole mass, and to be oxidized in a few hours, the temperature would rise only a few degrees, and, under ordinary circumstances, this rise in temperature would be practically inappreciable.

The oxidation of masses of pyrites under certain conditions gives rise to the formation of ferrous sulphate and sulphur dioxide, with liberation of sulphur, and one might easily imagine that this free sulphur, which has an igniting point of 250° C., would play an important part in the action by lowering the point of ignition. This, however, could only happen with large masses of pyrites undergoing oxidation, and with the small amount of pyrites present in coal, supposing air were present in sufficient quantity to oxidize it, the sulphur formed would be converted into sulphur dioxide at temperatures as low as 60° C. This oxidation of sulphur at low temperatures is an action not generally known, but in my experiments I have found it takes place with considerable rapidity. The only way in which pyrites can assist the spontaneous ignition of coal is that when it oxidizes, it swells and splits up the coal, thus exposing fresh surfaces to the action of the atmospheric oxygen.

I have carefully determined the igniting points of several kinds of coal, and find that

Cannel coal ignites at...	698° F. = 370° C.
Hartlepool coal ignites at....	766° F. = 408° C.
Lignite coal ignites at........	842° F. = 450° C.
Welsh steam coal ignites at..	870° F. = 477° C.

So that it is impossible for the small trace of pyrites scattered through a large mass of coal, and slowly undergoing oxidation, to raise the temperature to the necessary degree.

When coal is heating, a distinctive and penetrating odor is evolved, which is the same as that noticed when wood is scorched, and the gases produced consist of nitrogen, water vapor, carbon dioxide, carbon monoxide, hydrocarbons of the paraffin series, and sulphureted hydrogen, the presence of the latter gas showing beyond doubt that oxidation of the sulphur has nothing to do with the action.

Ever since coal has been generally adopted as a fuel, it has been recognized that great care was necessary in the storing and shipping of masses exceeding one thousand tons, and if the coal has been stored wet or in a broken state, firing or heating of the mass has frequently taken place. Much inconvenience and loss has been caused by this on shore, but the real danger has occurred during shipment, and owing to this many a vessel has been lost with all hands, without any record of the calamity reaching shore.

Owing to the greater facility for treating the coal when it becomes heated on shore in coal stores and gas works, absolute ignition only rarely takes place, and it is mainly from evidence obtained in the case of coal cargoes that we learn most as to the causes which lead to it.

Coal is a substance of purely vegetable origin, formed out of contact with air, by long exposure to heat and pressure, from the woody fiber and resinous constituents of a monster vegetation which flourished long before the earth was inhabited by man. Coal therefore may be looked upon as a form of charcoal, which having been formed at a temperature lower than that of the charcoal burner's heap, and under great pressure, is very dense, and still contains a quantity of those constituents which, in the ordinary burning, are driven off as wood naphtha, tar, etc., and these bodies consist of compounds containing essentially carbon and hydrogen, together with a little oxygen and nitrogen, and form the volatile matter and hydrocarbons of the coal. Coal also contains, besides these, certain mineral bodies, which were present in the fiber and sap of the original wood, and these form the ash which is left behind on the coal being burnt. These mineral substances consist almost entirely of gypsum or sulphate of lime, silica, and alumina, together with some oxide of iron, which gives the color to the reddish-brown ash of many coals, and which has been formed by the decomposition of the pyrites in the original coal.

The mineral constituents of coal are the only ones, with the exception of the pyrites, that play no part in the phenomena attending the heating and spontaneous ignition of coal, and we need therefore only regard the actions which take place when the carbon, hydrocarbons, and pyrites in freshly won coal come in contact with air and moisture.

Certain kinds of coal exhibit the same power of absorbing gases which charcoal has, although to a less degree. The absorptive power of new coal due to this surface attraction varies, but the least absorbent will take up one and a quarter times its own volume of oxygen, while in some coal more than three times their volume of the gas is absorbed, which gives rise to an increase in temperature, and tends to increase the rate of the action which is going on, but is rarely sufficient to bring about spontaneous ignition, as only about one-third the amount of oxygen being absorbed by coal that is taken up by charcoal, and the action being much slower, tends to prevent the temperature reaching the high ignition point of the coal.

All coal contains a certain proportion of hydrogen, with which some of the carbon is combined, together with the nitrogen and oxygen, forming the volatile matter in the coal. The amount of this volatile matter varies greatly, anthracite containing the smallest quantity, and cannel and shale the largest. When the carbon of the coal absorbs oxygen, the compressed gas becomes chemically very active, and soon commences to combine with the carbon and hydrogen of the bituminous portions, converting them into carbon dioxide and water vapor. As the temperature rises so this chemical activity increases, so that the heat generated by the absorption of the oxygen causes it to rapidly enter into chemical combination. This kind of chemical combination—oxidation—is always accompanied by heat, and this further rise of temperature helps the rapidity of oxidation, so that the temperature rises steadily; and this taking place in a large mass of coal, which from physical causes is an admirable non-conductor, will often cause such heating of the mass that if sufficient air can pass into the heap in order to continue the action the igniting point of the coal will be reached.

It has been suggested that very bituminous coal, such as cannel and shale, are liable to spontaneous ignition from the fact that heavy oils would exude from them on a rise of temperature, and that these, by oxidizing, might produce rapid heating. Experiment, however, shows that this is not the case, and that the heavy mineral oils have a decided effect in retarding heating.

We can now trace the actions which culminate in ignition. As soon as the coal is brought to bank, absorption of oxygen commences, but except under rare conditions the coal does not heat to any great extent, as the exposed surface is comparatively small, and the largeness of the masses allows of the air having free access to all parts, so keeping down the temperature. After the coal has been screened and the large pieces of pyrites picked out, it is put in trucks. Here it begins to get broken up, owing to the many joltings and shuntings, and so offers a larger surface to the action of the air. When it has arrived at the ship, it is further broken up by being shot down the tips or shoots, and more harm is done at this than at any other period, for the coal is broken by reason of the distance it has to fall, and it has to bear the impact of every succeeding load falling upon it, and it rapidly becomes slack, so that the under part of the ship load is a dense mass of small coal, which soon rises in temperature by reason of the large surface exposed to the air and the consequent absorption of oxygen. This sets up chemical combination between the oxygen absorbed by the coal and the hydrocarbons, and in some cases culminates in combustion.

It is found that the mass of coal exercises a most important action in the liability to spontaneous combustion, as although with 500 tons of coal to the cargo the cases of spontaneous combustion amount to only about ¼ per cent., when the bulk is increased to 2,000 tons cases of spontaneous combustion rise to 9 per cent., this being due to the fact that the larger the cargo the more non-conducting material will there be to keep in the heat, and also to the fact that the breaking up of the coal and the exposing fresh surfaces will, of course, increase with increase in mass; and it is also found that coal cargoes sent to European ports rarely undergo spontaneous combustion, while the number of cases rise to a startling extent in shipments made to Asia, Africa and America. The result is partly due to the length of time the cargo is in the vessel, the absorption and oxidation being a comparatively slow process, but the main cause is the increase of heat in the tropics, which causes the action to become more rapid; and if statistics had been taken, most of the ships would have been found to have developed active combustion somewhere about the neighborhood of the Cape, the action fostered in the tropics having raised the temperature to the igniting point by that time.

Moisture has a most remarkable effect upon the spontaneous ignition of coal. The absorption of oxygen is at first retarded by external wetting, but after a time the presence of moisture accelerates the action of the absorbed oxygen upon the coal, and so causes a serious increase of heat. The researches of Cowper, Baker, Dixon and others, have of late years so fully shown the important part which moisture plays in actions of this kind, that it is now recognized as a most important factor. A very marked case of the influence of moisture came under my notice a few months ago. A ship took in a cargo of coal at a South Welsh port, the weather being fine and dry while she was loading at the main hatch, but wet while she was taking in the coal at the after hatch, the result being that the temperature in a few days was uniformly about 10° higher in the coal that had been loaded wet than in the dry portion of the cargo, spontaneous ignition being the final result at the after hatch.

In order to prevent the spontaneous ignition of large masses of coal, it is manifest that every precaution should be taken during loading or storing to prevent crushing of the coal, and on no account must a large accumulation of small coal be allowed. Where possible the depth of coal in the store should not exceed 6 to 8 feet, and under no conditions must steam pipes or flues be allowed so near the mass of coal as to give rise to any increase of temperature. These precautions would amply suffice to prevent spontaneous ignition in stored coal on land, while special precautions would have to be taken in the case of coal for shipment.

Perhaps the commonest case of spontaneous combustion is the ignition of oily waste or greasy cotton rags. Nearly all vegetable and animal oils have the power of slowly absorbing oxygen, and in some of them this goes on with considerable rapidity, with conversion of the oil into a resin, a property which gives them the power of drying, and causes a considerable rise of temperature. A mass of oil, however, only exposes a very small surface to the oxidizing influence of the air, but when such oil comes to be spread upon any non-conducting fabric, the oxidation is very rapid, and the non-conducting power of the fiber of the fabric prevents the rapid dispersion of the heat, with the result that even a small quantity of such oily substance will readily inflame.

There are plenty of well authenticated cases in which even a handful of oily cotton waste, which has been used for polishing furniture, has ignited when thrown on one side, and caused most disastrous fires. Just twenty years ago Mr. Galletly read a most valuable paper before the Chemical Section of the British Association, in which he showed that the liability of oils to produce spontaneous combustion was in proportion to their tendency to dry. If a substance like cotton waste be rendered oily with anything except the mineral oils, it acquires the power of taking up oxygen from the air, and this gives rise to heat. The oxidation is slow at ordinary temperatures, and accordingly it may be some time before the increase of temperature becomes manifest; but when this point is reached, the action proceeds with great rapidity, and the point of ignition is reached in a very short

time, and then the mass bursts into flame. If the oily matter be placed in a warm position at first, spontaneous ignition may take place within a few hours, or even minutes. Gallety found that oily cotton at ordinary temperatures took some days to heat and ignite, while if placed in a chamber warmed to 130° to 170° F. (54° to 76° C.) the cotton greasy with boiled linseed ignited in 1 hour 15 minutes, and olive oil on cotton in 5 hours; and in a chamber heated from 80° to 200° F. (82° to 93° C.) olive oil on cotton ignited in two hours.

Cases of spontaneous combustion due to this cause have been more abundant than from any other, and cases are even on record where serious fires have resulted from sparrows using oily waste in the construction of their nests. In all well regulated workshops the orders against allowing any accumulation of oily waste are very stringent, and the most reasonable precaution to be taken is that all oily material when done with should be thrown into a metal vessel containing water, or which, at any rate, can be either emptied of waste or filled with water at night. If a sheet of cotton be hanging in a warm room and is splashed with oil, a hole will often be found charred in the fabric by the next morning, while if a few drops of a drying oil be allowed to fall on powdered charcoal or lampblack, ignition is almost certain to follow in a few hours.

Another common case of spontaneous ignition is that of haystacks which have been made up before the grass has been thoroughly dried, this being due to the sap left in the vegetable fiber undergoing fermentation, which, being a process of oxidation, gives rise to heat. This heat is kept in by the surrounding hay, which is an admirable non-conductor of heat, and gradually increases until the ignition point of the mass is reached, when the stack bursts into flame. In some cases the action does not go as far as this, and we often see the inside of a haystack charred to an almost black color, showing that the action has stopped but little short of the point required to give active combustion, this being probably due to the stack having been very closely built, and the access of air to the center being small, and in some cases when such a rick is cut, the air coming in contact with the central portion causes active ignition. If hay has once been properly dried and then becomes wet with rain, spontaneous ignition hardly ever takes place, although the hay becomes mouldy, and it is evident that the action which leads to ignition of the hay is fermentation of the sap.

Having now discussed the more common cases of spontaneous ignition, and seen that in every case it is due to rise of temperature, brought about by chemical action until the igniting point of the substance is reached, we are in a position to understand the impossibility of spontaneous combustion taking place in the human body.

The process of respiration by which the tissues of the body used up in every action, voluntary or involuntary, are got rid of by a process of slow combustion, gives a normal temperature to the living body, and it might seem at first sight possible, by preventing the escape of such temperature, to increase it to a point at which ignition might be possible; but we know by experience that the effect of swathing the body in nonconducting materials, so as to prevent the escape of heat from it, results in profuse perspiration, and before the living flesh could undergo combustion it would be necessary to drive from it the whole of the moisture which it contains.

The human body contains from 75 to 80 per cent. of its weight of water, and in order to evaporate this amount an enormous amount of heat would be required and life would have been impossible long before the necessary dryness of the mass had been arrived at. In fact, the moisture present in the body may be looked upon as its great safeguard against the effect of heat, and it is perfectly possible for a living man to remain in an oven which would roast a steak or cook an egg; the evaporation of water from the skin taking up so much heat that the temperature of the living flesh would never rise above a certain point until the moisture was exhausted. It used to be supposed that the cases of spontaneous combustion took place in people whose intemperate habits had caused the body to become saturated with alcohol, and that it was this substance which caused its ready ignition; but as Liebig pointed out some forty years ago, the presence of the alcohol could have no effect, as if we take a sponge and soak it in spirits of wine and ignite it, the alcohol burns away and leaves the sponge untouched, and the same thing would undoubtedly happen in the case of the living flesh.

In this lecture I have tried to bring before you the important fact that spontaneous combustion merely means that the heat due to chemical actions taking place in any substance, heat which has been unable to escape, has raised the temperature to the point of ignition, a point at which slow combustion passes into rapid combustion with manifestation of incandescence; and in speaking of spontaneous combustion we must clearly remember that it represents merely the acceleration of an action which has been going on slowly and surely, although our senses may have been too deadened to detect it, and that if we wished to be hypercritical, "Unaided Ignition," or "Natural Ignition," would be a far more correct term to apply to it than "Spontaneous Combustion."

COLOR REACTIONS OF CERTAIN AROMATIC TRIOXIDE COMPOUNDS.

By J. STAHL.

THE reactions mentioned occur in the cases of pyrogallol, gallic acid, pyrogallocarbonic acid, and tannin. In all these substances alkalies, with the simultaneous action of the oxygen of the air, produce brown or brownish red colors, even if the trioxy-compounds are present only in very minute quantities.

One one-thousandth mgrm. of pyrogallol gives the reaction with ammonia, and soda lye with $\frac{2}{1000}$ mgrm.; $\frac{2}{1000}$ mgrm. gallic acid and tannin and $\frac{1}{100}$ mgrm. pyrogallocarbonic acid yield the reactions.

In a series of other reactions given for the trioxy-compounds, *e. g.*, potassium cyanide, sodium nitroprusside, arseniates, etc., the author ascribes the result to the alkalinity of the reagents, the other components merely producing slight modifications in the color.

Baryta and lime water give the above named trioxide compounds the same color reactions as the true alkalies. Other phenols give with the alkaline earths yellow or reddish tones (resorcine, hydroquinone, phloroglucine) or no colorations (α-naphthol, thymol, paracresol). β naphthol turns bluish; pyrocatechine, first violet, afterward greenish black.

As regards the reactions—none of them characteristic—produced by osmic acid, molybdic acid, and solutions of chloride of lime, as also by the oxides of nitrogen and the compounds of chromic acid, we must refer to the original.

The behavior of the trioxy compounds with the compounds of iron is characteristic. Pyrogallocarbonic acid yields with concentrated solution of ferric chloride a greenish brown coloration or, if much diluted, a violet.

The most sensitive reaction for pyrogallol ($\frac{5}{1000}$ mgrm.) is a mixture of ferric chloride and potassium ferricyanide, which, in consequence of the reduction of the ferric chloride to the ferrous state, gives a precipitate of Turnbull's blue. Gallic acid, in the absence of air, is not affected by ferrous sulphate.—*Zeit. Anal. Chemie* and *Pharm. Central Halle; Chem. News.*

THE ELECTROLYSIS OF COMMON SALT.

FORMS of apparatus devised for effecting the electrolysis of common salt solution, and collecting the products set free about the electrodes, may be divided into two classes: Those having porous partitions between electrodes and those without, but having some other device, chemical or mechanical, for collecting or by which the products may be collected.

Of porous partitions, of course, there are a great many forms, but no practical data based upon their continued use appear to exist, and it will probably be some time before they are shown to be of much practical use for separating two such products as chlorine and sodium hydrate in solution, which is always above normal temperatures.

Of the method of employing mercury as the cathode, as a carrier of sodium from the electrolyte to another chamber containing water, in which the sodium is supposed to be given up and caustic soda formed, all that can at present be said with regard to it in the absence of working data is that sodium requires a higher electromotive force than hydrogen to liberate, and, therefore, represents greater expenditure of fuel; that it is almost impossible, for the same reason, to avoid the liberation of hydrogen, which, of course, forms an explosive mixture with chlorine; that the circulation of the mercury and appliances incidental thereto means complication, and that impurities or foreign matter settling upon the surface of the mercury will be detrimental to its action. But it is a question whether mercury is practicable for employment in alkali manufacture.

The only form of apparatus of which at present there appears to be any hopes in practical circles is that which has already gone through the ordeal of practical work at Snodland, Kent; and from which only any electrolytic caustic soda in a solid form and in bulk has been produced and sold. It is simple, automatic, compact, all parts are easily and cheaply renewable and no product is employed the loss of which can seriously affect the results.

The life of gas retort carbon as an anode in common salt solutions has been proved in this apparatus after night and day work for over a twelvemonth. Happily, it is much longer than was anticipated by the most sanguine, there being no difficulty whatever in constructing a cheap anode to last six months or longer.

The average efficiency of the apparatus on the basis of 310 ampere hours to the pound of salt is considerably over 80 per cent., maintainable until the solution attains 15 per cent. alkali, Na_2O, from which 70 per cent. is now being produced of excellent color and purity in the well-known commercial form, in drums; manufacturers and others who have had it reporting upon it very favorably, as well as the bleaching powder produced.

The difference of potential at the terminals of the tanks, each having a capacity of 60 cubic feet, has been brought down by degrees to 4 volts, with a current of 500 amperes: so that the energy consumption can be calculated therefrom and compared with other methods of manufacture. In round figures one-half of the voltage may be said to be employed in overcoming the counter electromotive force from which the resistance proper of the tank is easily calculated.

A good margin of profit can be shown after deducting all costs and expenses incidental to a practical works, and nothing appears to stand in the way of the growth of this important new industry, which, we hope, may be the forerunner of others in the electrical world of a like progressive character.—*The Electrical Review.*

THE ALUMINUM COMPANY, LIMITED.

The sixth annual meeting of the shareholders of this company was held recently at the Cannon Street Hotel, London, under the presidency of Mr. G. W. Balfour, M.P. After referring to the actual financial position of the company, the chairman stated that hardly one of the processes with which they started was now in use at Oldbury, and this would indicate to them the difficulties against which the board and the management had had to contend. The title of the company had, in fact, become a misnomer, since they no longer produced aluminum. They had developed the trade in sodium, partly by finding new uses for it and partly by reducing the cost of production; and one material they manufactured—peroxide of sodium—was a completely new commercial product, in which they already did a very large business. Their new electro-chemical process, which was invented by their colleague, Mr. Castner, was for the manufacture of caustic soda and chlorine direct from common salt, by electrolysis. The process turned out the material in a state of chemical purity, and, they believed, at a very much lower price than at present, and it reached in efficiency very close to the margin of what was theoretically possible. Sir Henry Roscoe, M.P., seconded the motion, remarking that he could indorse the chairman's statement, that in future the mode of making sodium would be by a process similar to that which the company now had in hand. The motion was unanimously adopted. A resolution was afterward passed for reducing the capital from £400,000 to £80,000 by canceling capital which had been called up, but was unrepresented by available assets to the extent of £4 a share and reducing the nominal value of the shares to £1 each.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,

361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

98.

nt.

any
ars a

n the
Price,

like-
early.
$3.50

IERI-
PPLE-

, and

Y.

PAGE

ct-
en
m-
nt
as
he
es
sk

k.

!